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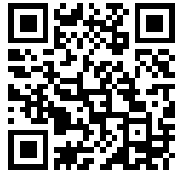

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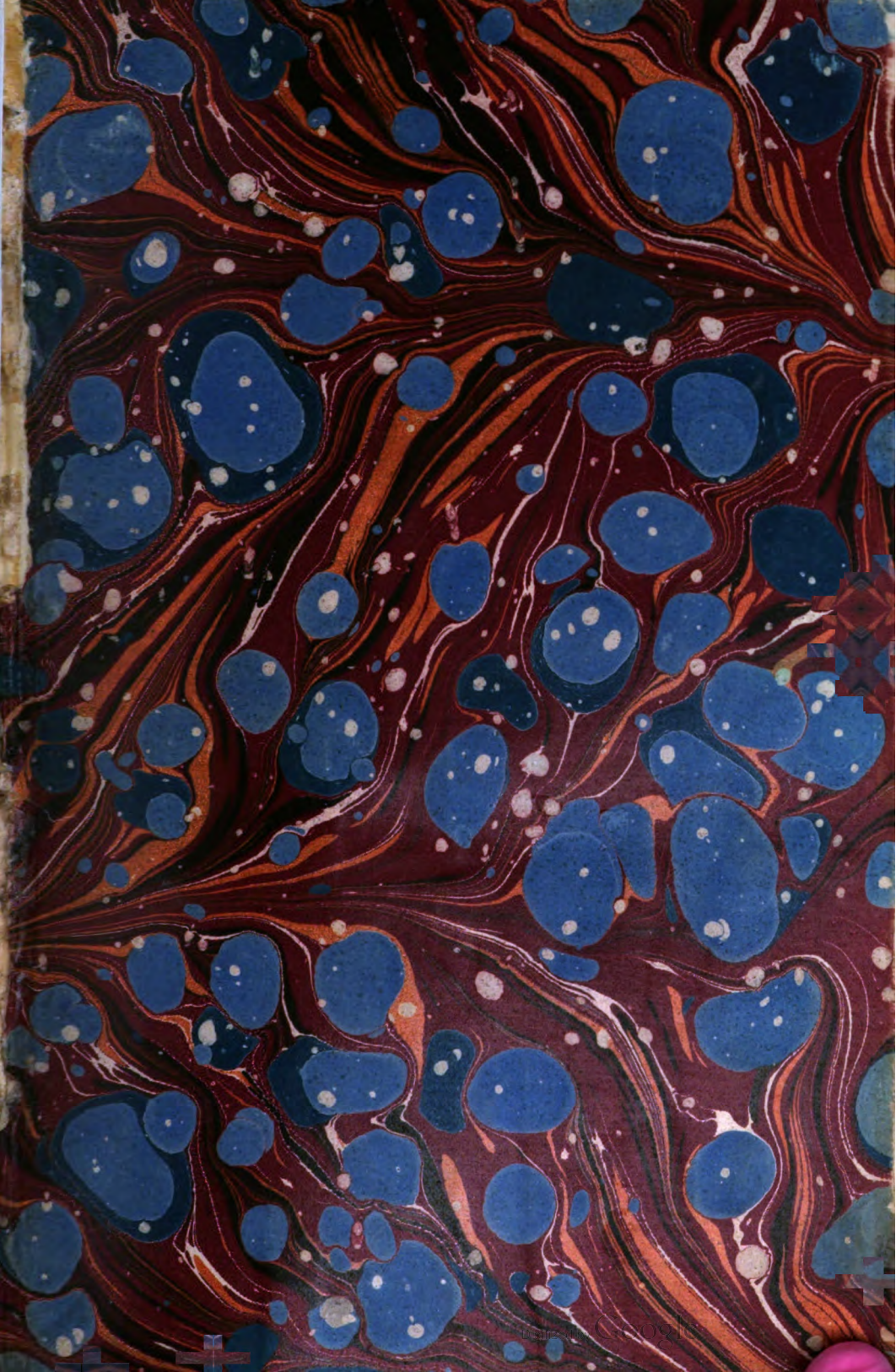

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW.

VOL. IV.

PUBLISHED BY THE SOCIETY,
AT THEIR ROOMS IN ANDERSON'S UNIVERSITY BUILDINGS.
1874.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

I.—*On the* SUTHERLANDSHIRE GOLD FIELDS. By MR. WM. CAMERON.

(Read 27th January, 1870.)

IT is now about four years since I had the honour of reading, before this Society, a paper on the auriferous rocks and drifts of Victoria.* In concluding that paper I ventured to suggest, that as history showed there had been at one time remunerative gold mines in Scotland, it was quite possible that there might yet be found in this country places where, with improved modern appliances, the search for the precious metal could now be profitably carried on. What I then merely hazarded as a conjecture has since been realized as a fact; and it now affords me much pleasure to lay before the Society the results of some of the experiences of a practical digger on a modern Scottish gold field.

Early in March of last year, accompanied by an old Australian companion, a thorough miner, I started for the Sutherland diggings, where we spent about five weeks in prosecuting our investigations as to the true nature and value of these fields. And I may state that every facility was afforded us by the agents and representatives of his Grace the Duke of Sutherland.

I shall not take up your time with any narratives of personal adventure, further than to remark that gold digging in mid-winter, amongst northern snows and ice, is no fancy occupation, and that repudiating the *role* of feather-bed diggers we went to work in thorough earnest.

The gold fields of Sutherland, so far as at present known, all lie within a radius of about ten miles around Benuarie, shown on the

*Transactions, Vol. II. p. 117.

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rough sketch map produced. The gold has hitherto been found chiefly along the valleys or straths of the tributary burns of the Ullie, or Helmsdale river, as well as in the flats and bends of that stream.

The principal burns worked have been the Kildonan, first discovered, the Suisgill, pronounced *Sheeshgill*, and the Torrish. Those streams are known as the Kildonan diggings. Gold has also been found in the Altenbraichich, the Cinpreas, and the Craggie, all flowing into the Ullie. On the south side of the dividing range, called the Crask, gold has also been found in the Smeoral, a burn which falls into Loch Brora at Gordon Bush, a most picturesque spot, and a favourite resort of the ducal family. This is what was called the Gordon Bush diggings. Further west, in another tributary of the Brora, called in Gaelic *Uisghe Dubh*, but in English, Black Water, gold has also been found, but here working was prohibited, and I may further add that, from 1st January last, all the gold workings have been closed, as the amount of licence fees did not compensate the Duke for the damages which he would have to pay his tenants, the sheep farmers; and as this forms one of the practical difficulties or obstacles to profitable gold mining in the district, it may not be out of place to give a few words of explanation on the subject.

The greater part of the country, except the valley of the Ullie, consists of mountain moorland; and in winter, when the bitter blasts of snow and sleet force the sheep to look for shelter, the valleys of these burns are invaluable as affording both food and shelter, and but for them the sheep farmers would often have a very poor account of their flocks. The value, therefore, of these flats is not so much to be estimated by the extent of ground, as by the fact of their absolute necessity to the whole, and without them the sheep farms would very much deteriorate in grazing capacity. The presence of so many busy diggers scattered all along the streams frightens the sheep, and drives them away from their natural shelter. The consequence is that many of them die of cold and hunger, and thus the farmer has a claim upon the Duke for damages and reduction of rental.

The prominent geological features of the country are the lower Silurian rocks, consisting of gneiss, mica—schist, quartzite, and granite in various forms, with occasional quartz veins—these latter, however, are not very plentiful. There is also along the

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coast line a belt of large-grained granite, with felspar. Old Red Sandstone here and there caps the Silurians, and Oolitic shales and sandstones are to be found along the line of coast above the valley of the Brora. Generally speaking, in the streams where gold is found, veins of flaggy granitoid rocks and schists prevail; and respecting the higher ground, it is well to say that there is everywhere so deep a deposit of bog, that it is only at considerable intervals that sections of the more elevated country can be obtained.

The flaggy formation, however, appears to be very general, for in small water-courses on the highest grounds of the Kildonan hills, we found it very fully developed, interbedded with schists splitting into thin laminæ, varying from a quarter of an inch to two inches in thickness. It was in the interstices between the laminæ of the schists that we found most gold.

Respecting the Oolite beds, we had no time to make any very minute examinations. We visited the quarries, which abound in interesting fossil remains; and the walls of Dunrobin Castle itself, which is built of this rock, might afford some study for the geologist, as in many of the stones sections of oolitic fossils may be detected. A belt of large-grained granite stretches from Berriedale to Kintradwell, a distance of about 30 miles. It has an average width o about four miles, and includes the Ord of Caithness.

The Old Red Sandstone, which covers a large portion of the eastern coast of Caithness, is seen in several places in the neighbourhood of the gold fields in isolated peaks, standing island-like amidst the surrounding ocean of Silurians.

Instances of these island-like peaks may be seen in the two Beinn Ghriams—the Beinn Ghriam Beg and the Beinn Ghriam Mor—the Suidhe N'Fhir Baigh (or little chield's seat), pronounced See, Niar, Vaig, Mor Beinn, Gioch, Smian, and Carn Ruadh.

The next patch of Old Red Sandstone extends from Kildonan south, capping the Crask, crossing the country at the head of the streams running into the sea south of Helmsdale, and covering half of the country around Loch Brora. This superficial sketch of the general geological features of the country will suffice for the illustration of the present subject: a more detailed and scientific account of the geological structure of the Sutherland gold-fields, which I should strongly recommend any one interested in the subject to read, is contained in a paper read by the Rev. Mr.

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Joass, of Golspie, before the Geological Society of London, with an introduction by Sir Roderick I. Murchison. Mr. Joass is a careful and very correct observer—and, what is of great importance, an unprejudiced one—and his paper is decidedly the best upon the subject which has yet appeared. It will be found in the 28th vol. of the Quarterly Journal of the Geological Society of London, August 1, 1869.

Before proceeding to a description of the gold fields themselves, it may be as well to direct attention to the general question, as to the source of the precious metal, with reference to certain theories propounded by Sir Roderick I. Murchison, Mr. Joass, Mr. Campbell of Islay, and others, so that the details which here follow may be considered with a view to their bearing upon the theory of either.

Sir Roderick I. Murchison has determined the order of the geological structure of Sutherlandshire to be as follows:—"Beginning at the west coast, fundamental gneiss or Laurentian rocks of the Northern Highlands, great masses of sandstone and conglomerate of Cambrian age overlying quartz rocks and limestones of Lower Silurian age. These Lower Silurian rocks, dipping to the east south-east, become more and more crystalline as they trend in that direction; and when perforated by bosses of eruptive rocks, roll over in undulations in a highly metamorphosed condition, until surmounted unconformably by the Old Red Sandstone and younger deposits of the eastern coast." He points to the peculiarity of outline of the mountainous regions of Sutherland and Ross as "presenting a steep and rapid escarpment, down which the waters cascade to the western shore, whilst they flow along a gentle slope for many miles to the eastern shore." Thus the parting of the waters in this region lies within four or five miles, and sometimes less, from the western shore; whilst it is from 70 to 80 miles from the eastern shore, in which the waters flow over the metamorphic Lower Silurian rocks, with occasional bosses of granite and other intrusive rocks. By means of glacial action, the great mass of detritus from the Western and Central Highlands has been transported eastward; and Sir Roderick is of opinion that the gold debris found near Kildonan is the result of abrasion of granitic and metamorphic Lower Silurian rocks in the interior. He is of opinion that certain valleys of the long eastern slopes of Ross-shire will also be found to yield gold, and notes that the gold-bearing detritus of

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Sutherland occur in a district where exist the most striking evidences of granitic eruption, and highly metamorphosed rocks. In seeking to trace the source of the gold, he puts aside the Laurentian, Cambrian, and Lower Silurian rocks, and attributes the parentage of the precious metal to the next series, consisting of chloritic micaceous flags and schists, which, as they dip to E.S.E., become more and more gneissic in character, and are perforated at intervals by granitic and porphyritic rocks. He finally concludes that the great central plateau in Sutherland is the source of the gold, and is of opinion that there is little chance of discovering here any notable bodies of rock *in situ* charged with rich auriferous bands analogous to those which are associated with the Lower Silurian slates and schists of Australia and California. Such is a brief digest of Sir Roderick's latest propounded views on the subject.

Mr. Joass, who notices the great prevalence of binary granites in the immediate vicinity of the diggings, observes that the detritus accompanying the gold is of this character, and that it is rarely found in any quantity where these granites are absent. He is inclined to infer that the granite form may yet be found to be the matrix of the gold, and remarks that the material in which granular gold occurs—namely, the detritus—"is not necessarily far travelled, for it includes boulders of apparently local origin. It has been arranged by water; but probably that of the streams near which it lies, and not that of the sea, judging from the unwashed moraines which occur in the lower valley of the Brora." He holds that "experience suggests no wide-spread deposit, the result of extensive glacial action, but several independent centres connected with the local rocks."

Mr. Campbell of Islay, the author of "Frost and Fire," has published a pamphlet, entitled "Something from Sutherland," in which he supports the glacial theory; points to the central mountains of Sutherland, such as Ben Clibrich and others, as likely to be gold-producing; refers to the existence of gold in Unst in Shetland, and, still further to Lapland and Scandinavia, where the same formation exists, and where gold has been found in the river drifts, and refers to data collected by himself and others, shewing the curves of the glacial flow, and concludes, "It is probable that the gold and drift come from the old Silurian rocks, and down the watershed of Sutherland. It is possible, that the drift came from Scandinavia, or from the Polar basin." I

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confess that the question is still a puzzle to me; but the following narration of facts will serve to shew in what direction the observations of the working gold-digger would seem to point.

Beginning then with the Kildonan diggings, it will be seen that the Ullie or Helmsdale is one of the main watersheds from west to east. The stream where gold was first discovered is the Kildonan, which has ever since continued to be the most favoured resort of the diggers; a fact, the inference of which is perhaps a little weakened by the circumstance of its being three miles nearer to Helmsdale than the Suisgill, the next best gold-bearing stream, if not its equal. With many the Suisgill was the favourite; but taking the whole period of the digging operations into account, the Kildonan has, on the average, had the greater number of miners working upon it. The Torrish, which is about half-way between Helmsdale and Kildonan, was never very extensively worked, and we may therefore safely infer that it was a poor field. The Alt en Braichich was also very partially worked. The Suisgill, from which heavy gold was obtained, occasionally vied with the Kildonan, and the Cinn Preas was for long, if not altogether, forbidden ground to the digger.

A high border or dividing range of quartzite and granite appears to run all the way up the valley of the Ullie. The streams have at various points cut through this, forming precipitous gaps, out of which picturesque cascades leap to the waters below. To reach any of the gold diggings it was necessary to cross this range before the upper bend of the golden streams could be reached. It would be well to note this range, as its position must, we think, affect the question of the distribution of the drift.

Leaving for a moment the mouth of these streams, we will place ourselves upon the top of the range which divides the water sheds of Sutherland and Caithness, and along which runs for a short distance the boundary march between the counties.

At the source of the Kildonan and Suisgill stands a prominent mountain called *Croch an Earnach*, or the Irishman's hill. At the summit it is strewn with flags of hard, cherty looking quartz, strewn about in chaotic heaps. The flags vary in thickness from two to four or five inches, We spent some time in searching for indications of a lode or vein whence this quartz sprung, but were unsuccessful, the whole surface of the hill being covered with heaps of these flags, whilst lower

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down a mantle of snow precluded any observations. A cold bitter wind blew as we clambered up through treacherous snow drifts to the summit of this hill, and we earnestly wished that the illustrious Hibernian who had stood god-father to it had endowed it with a perennial spring of his native poteen. Leaving this hill we made for the *Suidhe N'Fhir Baig*, which lies to the S. E. of *Croch an Earnach*, which we found to be a rugged peak of old red sandstone conglomerate, overlying the Silurians. We clambered up its rugged sides, and came upon the Little Chield's Seat, into which, turning our backs to the cold north wind, we gazed down the valley of the Langwell, or Berriedale Strath, upon a scene of rugged beauty well worth our labour. To the left stood the Maidens, two hills similar to *Croch an Earnach*. Further on, Morven rose like a gigantic sugar loaf towering over all the others, whilst the Scarabins, great quartz mountains, appeared to hem in the valley to the east.

The upper tributary streams of the Langwell and the Kildonan flow from within a very short distance of each other, whilst another fork of the Kildonan, as well as some tributaries of the Suisgill, take their rise from the western shoulder of *Croch an Earnach*.

The valley or strath of the Langwell and the Berriedale are the property of the Duke of Portland, and here mining was strictly prohibited—watchmen being set to prevent any attempt at prospecting. Notwithstanding their vigilance, however, some adventurous Australians contrived to have a trial at it, and said they obtained very good results; whilst a couple of lads who lived in this strath, and who came over to Kildonan to work, assured us that they had obtained better prospects there than on the Kildonan side.

There was, of course, a strong disposition on the part of the diggers to try this ground; all the more, perhaps, because it was prohibited, and no doubt many exaggerations were published about the wealth of this forbidden territory. We had no opportunity of testing for ourselves; and Mr Joass, who obtained permission from the Duke of Sutherland to examine the rocks in these straths, but who did not wash for gold, states that there is an absence of those rocks which seem to be associated with the richest deposits in the districts of Kildonan, and thinks these valleys less likely to prove auriferous than those situated on the Sutherland side of *Croch an Earnach* and the *Suidhe N'Fhir Baig*.

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A little to the south of the *Suidhe N'Fhir Baig*, there is another low shoulder of hill, from which flows one of the forks of the Torrish burn, and at this point we found the nearest approach to a well-developed quartz vein which we had yet seen, cropping up on the surface. It appeared to be a well-defined reef, but we had not time to give it a proper test; we broke up a quantity of it, however, and washed it carefully, but could find no traces of gold. The quartz was of what gold-diggers would call a "kindlier" appearance than any we had yet seen.

On either side of the Kildonan, high moorland hills trend towards the quartzite range, already referred to as running parallel with the Ullie, confining the stream and its surrounding flats into comparatively narrow limits, and from which small tributaries flow into the main burn. These tributaries occasionally afford very good sections of the rocks or drifts, and in nearly all of them gold is to be found. The Kildonan itself at some places cuts through sections of the rocks which crop out towards the surface, whilst in others high banks of sand and drift give evidence of a vast alluvial deposit. In some parts, the flats are flanked by deep gravel terraces of washed drift, upon the surface of which, amongst angular detritus, chiefly of a binary granite, we found traces of gold. In the course of our prospecting operations, we discovered gold in both of the tributaries rising from *Croch an Earnach*, as well as in that flowing from the base of the *Suidhe N'Fhir Baig*. At the junction of these three, the rocks are of a more schistoze character than those further down the stream, and here a very well developed quartz reef crops out, whilst in the neighbourhood, crossing the stream may be seen some remarkable veins of decomposed felspar and quartz forming a beautiful, fine, even grained sand, of a delicate pink white colour.

Further down the stream the rocks assume a more granitic character, interstratified with micaceous and chloritic schists, gneiss and quartzite, with here and there small quartz veins. Binary granites prevail to a large extent. These are generally very brittle, and split up readily into angular fragments. Varieties of granitic rocks are here very abundant, and often very perplexing, and in some portions of the stream are to be found bold masses resembling trap dykes. The strike of the rocks is about south-west and north-east; and it is to be remarked, that some of the best gold has been obtained where the bend of the stream forms an acute angle

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with the intersecting rocks. Thus, where the stream runs most nearly parallel with the strike of the rocks, the gold will most generally be found on the south or south-western bank, which forms, as it were, a v-like receptacle or natural ripple for the retention of the gold. As a rule, the miners generally preferred working in proximity to and below the reefs of a binary granite similar to the specimen exhibited, and also in the vicinity of a soft green schist of a spongy character. The earlier operations of the diggers were chiefly confined to the banks of the stream, where the bed rock was exposed to the surface, or at least above the level of the water. Gold is found chiefly in the lower drift, but very good quantities have been obtained in the various strata, even up to the roots of the heather. The drifts vary very much in character; in some portions of the stream we find a black ferruginous deposit of washed gravel and boulders, almost of the nature of a cement conglomerate. In others, a yellowish, felspathic, gritty drift contains the gold. There are very few, if any, beds of clayey wash-dirt; the general character of the drift being friable and easily washed. In some portions of the stream we found gold in a deposit of sand overlying the black ferruginous cement, in which also we obtained fair returns. Under this again, in a stratum of felspathic drift, separated from the above by a thin compact deposit of fine sand, we again found traces of the precious metal. As we have already said, however, the heaviest gold is generally to be found lying within the interstices between the bedding of the flags: in all cases it is necessary to lift the rock to the depth of a foot or even more, else the best gold may be left behind; and between the bedding planes, where one would think it almost impossible that it could find its way—the space being no more than a hair's-breadth—we have been surprised to find how far the gold had found its way below the surface. From the specimens of washed detritus exhibited, it will be seen that it is composed chiefly of granitiform rocks, schists, and gneiss—the small proportion, and in some instances the utter absence, of washed quartz, pebbles, and boulders being somewhat remarkable to anyone accustomed to the alluvial mines of California and Australia. In nearly all the residuum, as the last process of washing draws towards completion, a considerable quantity of titiniferous and magnetic iron, together with garnets, and a black crystalized metal something like "Black Jack," are to be found mingled with the gold—these materials, from their

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specific gravity, remaining last in the dish. In all cases, the washed detritus is of the same character as the local rocks, although occasionally we have found some washed pebbles of the old red sandstone not yet carried away to the ocean, and also occasionally nodules of red Hæmatite iron ore, a specimen of which is exhibited.

The gold is generally of a fine scaly character, but that found on the bed rock is often moderately "rough," as the diggers call it. In drawing the distinction between "scaly" and "nuggety" gold, the miners generally use the term "fine" and "coarse," or "rough," without meaning any reference whatever as to the assay quality of the metal.

On the larger flats, the lower stratum is crowded with large washed boulders, and it is found necessary to be very careful in washing these—the miners often using a scrubbing brush for the purpose. The gold often adheres very firmly to these boulders, and we doubt not that much of it has been lost through want of proper observance of this precaution. In some of the New Zealand diggings, where the gold is of the same fine scaly character as that of Kildonan, it is customary to roast these boulders in a kiln or in heaps, which seems to free the gold more readily, and thus much of the precious metal is saved that would otherwise be lost. Should peat (the only fuel available here) be suitable for this purpose, we think the experiment might be tried with advantage at Kildonan.

Latterly, the miners no longer confined themselves to the banks of the stream, but advanced as far as they were allowed into the flats; and as a fair number continued to pay their pound per month for the privilege of mining, it is only reasonable to infer that their labours were not so very ill requited as many were disposed to represent The bed of the stream has not, so far as I am aware, been worked with any marked success, although we ourselves saw some really very rough gold obtained from a portion which the claimholder had dammed off for the purpose. But the largest pools, where any very great deposit might be expected, are quite inaccessible except by aid of machinery; and as this has not yet been attempted, it is quite possible that some very nice "pockets" are distributed along the course of the burn. Well up the Kildonan, there are evidences of the course of the burn having changed from time to time, in the terraces which line its banks; and, doubtless, if some of these old courses could be properly opened

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up, leads of gold might be discovered. Coming down the course of the Kildonan, we find the valley becomes more contracted, until the stream cuts, as we have already said, through precipitous banks of the quartzite range which lines the Ullie; and here the miners' domain on this stream ceases. Gold, however, has been found below this fall, on the bank or terrace where lies the township Bhaile N'or, or the City of Gold; and even below that fair quantities have been obtained.

Crossing over the range between the Kildonan and the Suisgill, we found several small water-courses cutting through the bog, and a stratum of washed drift, about a foot and a-half to two feet thick, flowing towards the Suisgill, and rising just below the highest line of the ridge Here the bed of the stream was composed of flaggy granitoid rocks, with thinly laminated micaceous schists, very open and easily split. By picking up these laminæ from a depth of a foot to a foot and a-half, we obtained some very good quantities of gold; and in one of these little water-courses, called the Alt en Shavig, we found very satisfactory yields of fine gold—the best, indeed, of that description which we had obtained in Kildonan. Following down this stream, we come into the Suisgill, which is a burn about the same size as the Kildonan, but flanked by deeper deposits of drift and larger flats than the former. In this stream the gold is much rougher—*i.e.*, more nuggety—than that found on the Kildonan. It was here that the two-ounce nugget was obtained; an interesting stranger, which, unfortunately, has not yet found a neighbour. We had the pleasure of handling and inspecting this treasure, which is now we understand in the possession of His Grace the Duke of Sutherland. Here, several other nuggets of less pretension have, from time to time, been found. Upon the whole, we are disposed to think that the best specimens were obtained in the Suisgill. We prospected all the way up this stream, and in all its tributaries, and always found some gold; in one small sheep drain, running down from the moorland to the north-west bank, we found some fair specimens of roughish gold, one of which is amongst the specimens exhibited: I myself picked it out of the gravel lying on a binary granite reef, with a small trowel which I had in my hand at the time, the precious little mite being visible to the naked eye shining below the limpid stream which passed carelessly over it. We prosecuted our search here still further, and found some other samples of

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roughish gold; and subsequent explorers who followed in our wake were very successful at this spot. The point where we found the best gold was exactly at the junction between a binary granite reef and a green chloritic schist. Along the course of the Suisgill may be seen the same reefs which crop out on the Kildonan, the former affording better sections than the latter. Some short distance up the Suisgill, veins of decomposed felspar, intermingled with quartz—and which, when washed, yields a substance very similar to pure China clay—are to be found striking, as it were, through decomposed gneiss. We found these veins both running through gneiss and mica schist.

In nearly all the other streams the same peculiarities prevail, and it would be out of place here to repeat descriptions. Crossing the Ullie or Helmsdale, we ascended into the old red sandstone, which we crossed, and arrived at the Alt Smeoral, or Gordon Bush Burn. Here there are some extensive terraces of drift, in which moderate quantities of gold were obtained; and on the flats at the edge of the stream, in crevices of the rocks which contained veins of decomposed felspar and green chloritic schists, we found some very promising results. On this stream the black ferruginous cement also abounds, and is gold-bearing; and towards its junction with the Brora valley, it cuts through quartzites and red granite, in some places coated between the veins with a film of red Hæmatite. Crossing over from Alt Smeoral to the Blackwater, or Uisghe Dubh, we came upon a very perfect specimen of the old Pictish towers, called Castle Coll, which stands upon an island-like eminence. On one side there is a sheer precipice to the river of some 150 or 200 feet high, which shews some excellent sections of quartzitic and gneissic rocks; whilst on the other a deep ravine, apparently the bed of some old fork of the stream, seems to have served as a species of moat, making the position of this ancient fort all but impregnable, according to the ancient methods of warfare. In the Blackwater, we found in one tin dish (the first we washed) a specimen of shotty gold about the size of a pin-head, and since that some very fair washings were obtained by a friend who tried it subsequent to our visit. Here the rugged edges of the metamorphic rocks were very much exposed, and on the steep banks the drift deposit was comparatively small, and towards the mouth of the stream, below Castle Coll, it is angular and shingly. Gold has also been found on the Clyne Milton Burn. Further, we were informed by a couple

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of intelligent Australian miners that they had tried some of the sand on the seashore near Dunrobin Castle, and had obtained the "colour," as diggers call it—that is, one or two small specks of fine gold. No gold, however, has been found in the Kintradwell Burn, the Alt Choill or the Loth Beg; whilst the best results have been obtained from the Alt Smeoral or Gordon Bush, the Kildonan, and the Suisgill; and in all of these there is a striking similarity in the character of the rock formations and in the peculiarities of the drifts.

Thus, it will be seen that whilst gold, more or less, is pretty generally distributed throughout this part of Sutherland, it is most plentiful where the flaggy beds of granite, schist, and gneiss exist, and where the granites are of a binary character; in those streams where a hard red granite prevails, gold, if found at all, is generally in small quantities; and where it is found in such places, a search up the stream will reveal the existence of formations more or less resembling those of the Kildonan and Suisgill.

And here, before going further, it may not be out of place to remark upon a subject which, although not of geological bearing, is too interesting to pass unnoticed. I refer to the great number of Pictish Towers and prehistoric Tumuli dotted all over the country. Mr. Joass, who is the best authority upon these, and whose untiring labours have, with the aid of funds supplied by his Grace the Duke, brought to light some very interesting discoveries, is inclined to associate the erection of these Pictish Towers with the existence of the gold, which there is evidence to show was in that age worked by the natives. The correctness of this conclusion I am inclined to doubt, but his remarks are well worthy a perusal. Upwards of twenty of these towers may be counted within an area of little more than twenty miles square.

Coming back to the gold itself, the question, Where does it come from? is the most interesting problem, from a geological point of view.

The experiences of Australia and California prove quartz interbedded with argillaceous slates and sandstones to be the true matrix of gold in these countries. In Russia, likewise, the same holds good, and the general tendency amongst geologists is to attribute its origin to this source. The comparative absence of such a formation on the richest diggings of Sutherland has appa-

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rently led some, who have given their attention to the subject, to go further afield to trace the source of the precious metal, rather than ascribe its parentage to the rocks in the immediate vicinity where it is found. Accordingly, as I have already stated, Sir R. Murchison takes us to the Silurian plateau, towards the central and western portions of Sutherland, whilst Mr. Campbell hesitates whether to travel a little further, and carry us up to Lapland and the Polar regions. Both consider the vehicle of conveyance to have been ice; and, *ceteris paribus*, if the existence of the precious metal in Kildonan is due to the deposits of ice flows, it may as likely have come from Lapland and the North Pole as from anywhere else. Such being the origin of gold, it will be seen at once that the formation of the rocks where the golden drift is found has not necessarily any bearing whatever upon the question of its existence; and whatever be the formation, provided its contour be suitable for the retention of the gold and accompanying drifts, it should, according to this theory, be found wherever this glacial flow has covered the land. So wide and so little explored are the territories to which this theory points, that the absence of any discovery, up to this date, of gold *in situ* in any of them, is not so weakening in its effect, in so far as the probabilities of discovery in such vast wild regions are remote. On the other hand, the present diggings have been tolerably well explored, and no gold *in situ* has been discovered either. There is consequently, as yet, no definite proof of a local origin. Failing, then, to obtain information from the rocks, we must turn to the drifts and see what they have to tell us. If quartz veins similar to those of Australia and California are the parents of the gold, then how are we to account for the remarkable paucity of washed quartz boulders in the drift? If the icebergs brought the gold they must have brought the matrix too. They did not considerately crush it and wash it off for us first, and then bring us the precious metal ready for the market. Well, what drifts have we associated with the gold? Why, the very same materials that compose the rocks which surround them, and upon which they rest. Sir Roderick Murchison describes the interior plateau as consisting of chloritic and micaceous flags and schists, becoming more gneissic in character as they dip E.S.E., and perforated by granitic and porphyritic rocks. Well, we have in the Kildonan, Suisgill, and Alt Smeoral, all these rocks *in situ* and all these rocks in the drift. All are

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alike in character, and all gold-bearing. There is no special peculiarity belonging to the central plateau or the Polar basin pervading these drifts so as to point to any other than a local origin. In the drifts, as in the rocks on the diggings, we find a notable scarcity of quartz. The large boulders are all either of gneiss, quartzite, or granite, and the drift generally, as you will perceive from that washed off in your presence, for most part corresponds strictly with the local rocks.

Again, it is a fact that the character of the gold in the various streams differs materially. The Suisgill, for example, contains rougher gold than the Kildonan, and the Alt Smeoral or Gordon Bush varies from either. It was stated to us by an intelligent miner, who had sent gold from both streams to Edinburgh to be assayed, that they differed in their quality, that on the Suisgill being richer. For this, however, I am not prepared to vouch; I give the information as I got it.

In Australia, the character and quality of the gold varies much in every diggings, and the cause of its peculiarities is invariably traced to the lodes from which it originally sprung.

But if the golds in Suisgill, Kildonan, and Gordon Bush all came from one common source, miles away, or even from a variety of sources, the debris from which must have been indiscriminately mixed together, we should expect that any variations would be purely accidental, and common alike to all the valleys where this glacial detritus was deposited, whether originally from one or a hundred sources. Not so, however, is it with the Kildonan and Suisgill; each stream maintains its special character, each pointing to a special origin, due probably to some local peculiarity.

The theory which attributes a granitic origin to gold is not a new one; and although I have never, in my own experience, met with anything conclusive in its support, the circumstances of its existence on the Kildonan diggings are such as to bias one's mind very strongly towards this conclusion—at least, until a better case is made out for some other matrix.

On the plateau of Sutherland, Sir Roderick Murchison describes the formation to which he attributes the gold as "chloritic and micaceous flags and schists, which as they dip to E.S.E. become more and more gneissic in character, and perforated as they are at intervals by granitic and porphyritic rocks, have in all probability afforded the auriferous detritus of eastern Sutherland."

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We have in Kildonan and Suisgill chloritic micaceous flags, gneiss, quartzite, and granitic rocks. The drift found in the wash-dirt has, as far as we could learn, no speciality pervading it which points to any other than a local origin; indeed, for the most part, it seems strictly to correspond with the rocks in the neighbourhood. This, coupled with the fact that the diggers show a predilection for certain rocks, near which they imagine they will find most gold, and that they are as a rule all agreed in their particular choice of the rock, seems to point very strongly to a local origin. Upon the whole, the question is very perplexing, and, so long as gold *in situ* remains undiscovered, it will always remain an open one. Meanwhile, until more conclusive evidence is adduced in favour of a remote origin, I do not see why we should travel from the rocks where it is actually found; and I am disposed to coincide with what Mr. Joass says, that the facts hitherto discovered point to a granitiform matrix—probably binary—and that "they suggest no wide-spread deposit, the result of extensive glaciation, but to several independent centres connected with the local rocks."

With respect to the question as to whether these gold diggings will pay for working, I can only point to the fact that for nearly twelve months a considerable number of miners have continued to pay one pound per month to his Grace the Duke of Sutherland for the privilege of mining on his property, besides having to submit to a levy of ten per cent. royalty which is exacted by the Government upon all they find!

Moreover, to this latter tax may be attributed the utterly unreliable nature of the returns given in by the diggers. A more useless and mischievous tax was never imposed; it encouraged falsehood and perjury, and to it may be partly attributed the stoppage of an industry that at one time promised employment to a large population, which in certain seasons of the year is often reduced to great penury.

His Grace the Duke of Sutherland is entitled to the highest credit, and to the gratitude of the early Sutherland diggers, for the generous and liberal manner in which he allowed his grounds to be turned over and destroyed for months without exacting a penny from the miners. Yet I regret to say that when a few of the better class of diggers proposed to devote the proceeds of a day's work as a testimonial to his Grace, and a recognition of his kind-

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ness, the most miserable meanness was displayed. ' Upwards of 400 miners were working at the time, and of these a very small proportion gave anything at all, and even then not what they really obtained. This day's work, which has been quoted as an illustration of the poverty of the diggings, is of no value whatever as evidence, and is simply a disgrace to Kildonan.

The great desiderata for profitably working for gold are, a plentiful supply of water, a good fall to carry off the refuse, and machinery to pump the claims and wash the drift. All these nature has mostly provided: an abundant supply of water on all hands, not only sufficient to wash the drifts, but to drive powerful machinery, is here to be found; and whilst I doubt very much whether gold-mining could be profitably carried on for any length of time by the individual digger, I am decidedly of opinion that many portions of these fields would be remunerative, if worked in an extensive, systematic, and economical manner.

II. *On the* Section *on the* Crofthead and Kilmarnock Railway, *in* Cowden Glen, Neilston, Renfrewshire, *with remarks on the* Upper Boulder Clay. By Mr. Robert Craig, Langside, Beith, Corresponding Member.

(Read December 11, 1869.)

In making the above railway throughout Cowden Glen, the excavations laid open a series of beds, consisting of stratified clayey mud, sand, gravel, and peat. These beds, evidently of lacustrine origin, commence about three-fourths of a mile south-west from Crofthead, or Neilston Station, and continue in the cutting for nearly half a mile as it proceeds towards Shelford. On the east end of the stratified beds, the glen is less than 100 feet wide; the north side forming a bold escarpment nearly 80 feet high. The south side has less height, falling back in undulating knolls, and forming a rugged but not unpicturesque landscape. But as it extends towards Shelford, the hills on each side lose their escarpment character, falling back with more regular declivity, and giving the glen more the character of a valley, until, at Shelford, the breadth of the clay deposits, forming the bottom of the valley, is nearly half a mile broad. The glen, or valley, has been caused by a large break in a ridge of trap, which divides the carboniferous strata of the Levern valley from that of

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the Lugton, lying to the south-west of Shelford. The break in itself is of geological interest. The trap on its north side is that soft peculiar porphyrite of the Gleniffer range of hills, while on the south side it is porphyritic claystone, intercalated with layers of greenstone, and is certainly a subsequent deposit to the porphyrite of the north side.

At the point where the glen commences to widen, the trap forming the bottom, or floor of it, dips suddenly to the west, apparently leaving a large hollow, or chasm, which extends to the outthrow of the carboniferous strata at Shelford. This hollow is filled up with boulder clay or till, which has proven, as far as it has been cut into, to belong to the lower bed of the boulder clay, as known in the West of Scotland. The stratified deposits occupy hollows in the surface of this large deposit of boulder clay, and are, evidently, the silted-up *debris* of old lakes, a series of which appears to have occupied the valley, at one time, from Crofthead, Neilston, to Lugton Inn, Dunlop. The present Loch Libo, lying to the west of Shelford, is the only one of the series now remaining. This little lake is a long narrow sheet of water of eliptical shape, and this appears to have been the contour of those now silted up. Some of these small sheets of water have been of great depth, in proportion to their surface area; the one lying to the east of the boss of lower till, which divides these lacustrine beds into two sections, has had a depth of 60 feet at least on its south side. This has been ascertained from a series of bores put down along the line of railway to discover the thickness of the soft mud beds. This divisional boss of lower till, or boulder clay, rises about 20 feet above the level of the railway, and from 8 to 10 feet above the upper surface of the stratified deposits, and runs across the valley from side to side. Its breadth, taken at the level of the railway cutting, is 150 yards, and it inclines on each side at an angle of 15°, consequently the stratified deposits crop out against it at the same angle.

The stratified beds lying to the east of this boss have created some interest among geologists from the discovery of the skull and horn core of the *Bos primigenius*, and latterly of part of the horn of the extinct Irish elk, *Megaceros Hibernicus*, and a few bones of the horse, *Equus caballus*. The deposits forming this section have a length of 245 yards, and a breadth of from 60 to 300 feet. The depth of the stratified beds is about 60 feet on the south side,

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but whether this depth extends across the beds from rock to rock is a question for discussion, as a boss of the lower boulder clay appears to lie on the north side; and if this is in position, and not a slip that has descended from the hill above during the period of silting up, the beds will be comparatively shallow on this side.

The stratified beds consist of mud, sand, gravel, and peat. The mud is purest at the base of the deposits, and becomes mixed up with thin layers of sand and gravel as it approaches the top or upper surface. These mixed upper beds have a thickness of from 8 to 10 feet, but as they are very lenticular, a section taken every 20 feet would give a different measurement. The following section, taken near to the place where the antler of the extinct elk was found, may be taken as typical of the stratified beds as far as cut into. It was taken previous to the great slip in the beginning of October last, and represents a section of the north bank in vertical position :—

	Ft.	in.	pts
Boulder clay,	10	0	0
Clayey sand,	3	0	0
Peat,	1	5	0
Fine mud,	0	4	0
Peat,	0	5	0
Sand,	0	4	0
Clay,	0	0	6
Sand,	0	1	0
Mud,	0	0	3
Sand,	0	1	6
Mud,	0	0	3
Sand,	0	3	0
Mud,	0	0	3
Sand,	0	0	6
Clayey sand,	0	10	0
Peat, mixed with mud,	0	4	0
Gravel,	0	9	0
Clay,	0	2	0
Sand,	0	1	0
Peat, mixed with mud	0	1	0
Sand,	0	0	6
Mud,	0	1	0
Gravel,	0	8	0
Peat, mixed with mud,	0	9	0
Gravel,	0	4	0
Sand,	0	6	0
Gravel,	0	2	0
Sand,	0	7	0
Gravel,	0	3	0
Dark-coloured sand,	1	6	0
Mud cut into,	4	0	0
	27	2	3

The lenticular nature of the beds will be best understood by stating that the 1 foot 5 inch bed of peat, with the two underlying thin beds, were taken in the centre of a lenticular nest, 30 feet long, which thinned off, until the two peat beds became united at a thickness of 8 inches, the clay having thinned away to an almost imperceptible lamina in the peat. This bed extends across the surface of both deposits. It is very irregularly developed, being sometimes two feet in thickness, and at other parts reduced to six or eight inches. It is thickest around the margin of the deposits and becomes lesser developed towards their centre. It is full of mosses, sedges, and leaves, which either belonged to

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the land, or which grow in shallow water around the margin of lakes whose shores are soft and boggy. From this I infer it to have been the old land surface which grew and accumulated around the margin of the old lakes as they became silted up. The principal component of the bed, beside the mosses, is a sedge *Scirpus lacustris*. From a finely-preserved spikelet of the head of the latter, its identity with the modern species was ascertained. Fragments of the branches of *Betula alba*, leaves of *Salix alba*, twigs of *Caluna vulgaris* and *Vaccinum myrtillus* are found. A piece of the bark of *Pinus sylvestris* was found about one foot long, six inches broad, and half-an-inch thick. It was also in this bed where the skull and horn core of *Bos primigenius*, and the fragments of a horn and antlers of the extinct elk, *Megaceros Hibernicus*, were found—the former near to the centre of the railway cutting, about 5 or 6 feet from the surface, the latter about 30 feet farther into the hill side, north-west from where the *Bos* was found, and about 15 feet from the surface. J. A. Mahony, Esq., in his list of "Organic Remains found in Cowden Valley,"* says that "twigs of *Betula alba* were found in the lower leaf bed, but none in the upper. They are, however, plentiful in the upper, at least in certain parts of it. Where the horn of the elk was found the upper leaf or peat bed was nearly two feet thick, and not a spadeful of it could be taken up and split off in lamina, without revealing fragments of *Betula* and other twigs. Other parts of the bed were totally deficient in these remains.

As seen from the section given above, the beds intercalated betwixt the upper peat bed and the underlying mud, consist of sand, gravel, mud, and peat. These peat beds are nests of peaty matter embossed in the mud, sand, or gravel, and generally much mixed up with them. None of them had any very extended area across the deposits, and cannot with propriety be called beds. The mud was pure and free of stones, except where it had come into contact with slips of boulder clay. On its upper surface its character as a mud was very consistent, but in the bores put down to ascertain its depth, it changed towards its under surface into a tough brick clay of a brown colour. In the south side and centre of the deposit it was free of stones, not a pebble intercepting the spade or pick in

* *Geological Magazine*. Vol. VI., p. 390.

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removing it, while that on the side of the north bank was largely mixed up with stones and boulder clay. It was in the mud where the bones of the horse were found 25 feet below the surface, and would be on a horizon 15 feet lower than the one where the *Bos* was found.

As already stated, the matrix of these deposits is the lower boulder clay. It is seen underlying the mud all round its outcrop, except on the south margin where the mud rests upon the glaciated surface of the porphyritic claystone. On the opposite bank large masses of boulder clay have been slipping down from the valley side into the old lake as it has been silting up. These slips had come down during the time that the lake was being silted up, and were intercalated in the mud as tongues of boulder clay. See annexed Section, No. 2.

These were found to be more numerous on the north-east end. Although the section represents only two of these tongues, various smaller ones were noticed; and from the sand and mud mixed with the boulder clay forming the tongues, it may be inferred that their presence was due to slips which had taken place during the period of silting up. On the north bank, on the eastern extremity of the beds, a very extensive slip has taken place. Many hundreds of cubic yards have come down, apparently from the hill above, upon the mud bed at this place, and plunging into it with great force, had sunk deep into the bed, forcing it up around, and filling it with stones and fragments of boulder clay to the distance of 30 feet. That these were due to slips, and not to loads of boulder clay floated in upon cakes of ice, must be apparent to any one who considers the smallness of the old lake. A surface of water not more than 600 feet long in its greatest length, and on an average not more than 200 feet broad, could not be a receptacle for floats of ice loaded with such masses of clay as these tongues would have required. The just inference is to suppose a mass of boulder clay left upon the hillside above, and, loosened by the frosts and rains of winter, had come down into the old lake. That these had been going on from an early period of the lake's existence appears from their being found in the bores below the level of the railway cutting. Wherever these tongues were cut into, the superincumbent mass slipped away from the north bank, and after the slip in October last, which occurred after a very heavy rain, the solid boulder clay, was seen

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to project from under the stratified beds. Of the latter, a boss 60 yards long, rising from under the soft beds, and resting upon the rock of the northern bank, remains firm. The character of this boss and that of the slips are identical. Both are of the well-known tough, tenacious character peculiar to the lower till in the west of Scotland, and exceedingly full of striated stones from the size of fine gravel to more than 20 cwt.

Another small section, where the mud is intercalated with layers of boulder clay, was found in a cutting about a quarter of a mile west from Crofthead. This small section throws considerable light upon the mode of deposition of these tongues in the larger section, and is well worthy the attention of those who take an interest in the deposits of the valley. This section consists of alternate layers of mud identical in character with that of the larger section. The following is a section taken shortly after the cutting was laid open, and represents a vertical section of the north bank of the railway as it then existed. See annexed Section, No. 3.

This small section is only 60 feet long, and lies in a hollow betwixt a boss of lower till and the rock. The alternate layers of mud and boulder clay are from one foot to one foot three inches thick. The layers of boulder clay run into the boss of lower till lying on their east end. From the section of cutting removed both the mud and boulder clay inclines from the hillside, which at this place is very steep. Four layers of mud and as many of boulder clay are exposed above the level of the railway cutting. It has by some been supposed that these miniature beds are the result of floating cakes of ice loaded with boulder clay, or that each succession of mud shows a withdrawal of land ice, and each layer of boulder clay a return of the land ice; but it appears to me that the simple and more natural explanation is to refer the cause of their existence to a series of periodical slips from some mass of till left on the hill above, caused either by heavy rains or thaws, followed by rain; while the mud infers a pool of water in a state of rest lying in a hollow of the lower till. The whole was capped by about 10 feet of the reddish-coloured gravelly boulder clay found in the district, which will be noticed hereafter.

The other stratified deposits cut into are those lying further to the west of the divisional boss of boulder clay already referred to. These are similar to those already described. They consist of

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sand, gravel, and mud. The mud is entirely free from stones, and very fine as far as it is cut into. The railway cutting, which is about 15 feet deep, runs nearly straight through the centre of the stratified beds; and from the incline of the lower boulder clay upon which they rest, they probably have a further thickness of 30 or 40 feet. The sand and gravel beds on the top of the mud are much coarser than their equivalents in the deposits lying to the east of the divisional boss. They are mostly coarse gravel, as if the water passing from the one lake to the other left the heavier material in the first, and carried only the finer sediment into the second. With this exception, and that no slips of boulder clay have run into the lake, mixing itself with the silt, as far as the beds are seen the deposits of stratified matter in this section are identical with those in the other.

Contortions.—Considerable twisting or contortion occurs in the lower sand and mud beds, while those lying near the surface are comparatively free. They have no general persistent character, are twisted in all directions, and show much more in the neighbourhood of a slip than further off from it. The surface beds, and especially the peat bed, are free from any twisting whatever. In the western deposits, near to their east end, occur the only contortions of any magnitude in the beds. This crossed the cutting at an oblique angle running north-west. At one place it was so contorted, and the beds so folded over each other, that a rod put down perpendicular for a dozen of feet would have passed through the same bed four times. But even this one did not reach the surface, there being four to eight feet of stratified beds overlying it free from the folding of the under beds. A good example of twisting by a slip was observed in these beds after the large slip in October last. A portion of the beds of sand, gravel, and mud which the excavators were removing at the time remained standing when the slip took place. Prior to the slip this part of the beds were comparatively free from twisting, but after the slip took place they were heaved up from four to five feet, bent and twisted in all directions. The railway, which had been cut down to its proper level, was raised four feet, the sleepers and rails being displaced and thrown out as if by an explosion. The beds were all twisted and broken into crevices of 10 inches wide and downwards. A further rise took place, so that the soft mud along the line of railway has been raised from six to eight feet by this slip, and the

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beds contorted in a very curious manner. The slip was caused by the mud being cut into below the level of the tongues of boulder clay, which descend into it, thus freeing them of any support, and when the heavy rains of last autumn came, the whole overlying boulder clay, mud, and loam of the valley side slipped into the cutting. The length of this slip was above 200 yards, its breadth from 40 to 50 feet, and its height about 30 feet. It was heaviest on the two ends; a part of boulder clay, which rises from under the stratified beds, 60 yards long, near the centre of the slip, remains firm. The large mass forming the slip consisted of the stratified beds, boulder clay, mud, and loam, which rose above the bottom of the cutting, and had a depth on this north-west bank of more than 30 feet. The stratified mud intercalated with the tongues of boulder clay was much mixed up with stones, sand, and gravel; and these tongues of boulder clay were more gravelly than the large mass that had come down on the extreme north-east end, as if the clay had been partially reassorted in water. Otherwise it had all the character of the lower till.

The Upper Boulder Clay.—This bed of clay is very partially developed in the valley. A small boss of it overlies the stratified beds on the west end of the western beds, and another small boss of it spreads over the divisional boss of lower boulder clay, overlapping the ends of the stratified beds on both sides of it. This clay is very different in character from the lower boulder clay; it wants its tough tenacious character so marked in that of the West of Scotland; it is freer, of a more earthy and gravelly nature. Another marked characteristic of this upper bed, which I have not seen mentioned by any writer upon boulder clays, is the large quantity of underlying stratified clay held in it in lumps as boulders of clay. These are of all sizes, from that of a wafer to lumps of a cubic foot. It is also more persistent in colour than the lower bed, being always found of a reddish or ferruginous colour. This persistency has been solved, I believe, by Mr. John Young, Hunterian Museum, who is of opinion that it being free to the admission of the atmospheric air it has acted upon it, and oxygenising the iron contained in the clay gives it the reddish or ferruginous colour it universally has. The small boss lying on the west end of the western beds has a length of 300 feet, and a thickness of 8 feet in its greatest depth. The other boss which spreads over the divisional boss of

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lower till, and overlaps the end of the stratified beds resting upon it, has a length of 600 feet and a depth of 3 to 10 feet. The other small boss overlies the small section No. 3; it has a length of about 80 feet, and in its greatest depth a thickness of 10 feet. These are all the sections of this bed of upper boulder clay found in the valley. It is all developed on the north side, and it may be worth remarking that not a particle of it exists along the south side. It is also very remarkable that the lower bed of boulder clay has a greater development on the north side than on the south one, from where the glen widens at Milthride to west of Shelford; the former is filled with boulder clay, while on the opposite side the rock is left bare and exposed, and the lower till buried under stratified beds.

Age of Stratified Beds.—That these stratified beds belong to an age subsequent to that of the lower boulder clay appears to me to be a fact which admits of no question. As stated, they occupy hollows in the surface of the lower bed, and therefore belong to an age posterior to it. That the district existed as a land-surface, and free of ice, with a vegetation similar to that existing at present, is attested by more sections in the West of Scotland than these lacustrine deposits in Cowden Glen. At Overtoun and Hillhead, Beith, portions of an old land-surface have been laid bare in removing the surface beds from a limestone and sandstone quarry. Like the beds in Cowden Glen, these lie between the lower and upper boulder clays. At Overtoun, the intercalated bed is a fine blue-coloured brick clay, very full of the roots and stems of *Corylus avelana* nuts of the same, and the skeleton of a fern frond, plentiful in some places of the bed. Some of the stems were over two inches in diameter. At Hillhead, a similar bed of white clay with stems was found in the same position. In both places the beds were overlaid by a stratum of upper boulder clay from 4 to 5 feet thick. It was largely mixed with pieces of the intercalated bed, the pieces remaining entire and full of the stems, the same as the parent bed. This was particularly so at Hillhead.

Some eminent geologists claim for this upper boulder clay the same origin as that of the lower bed, viz., the production of land ice, and hence set down the Cowden Glen stratified beds and others of a like kind as interglacial. After long and minute study of the phenomena of both beds, grave doubts have arisen in my mind as to the correctness of this opinion. I believe no theory in

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geological science is more firmly established than the one which explains the origin of the lower boulder clay to have been due to land ice. But I question if the same can be said for the very slight development of gravelly ferruginous coloured clay, which is found lying upon a horizon higher than the old land surface which has existed in the period intervening between the two deposits. That an old land surface has existed in the West of Scotland, at least subsequent to the deposition of the lower bed or beds of boulder clay, and prior to the deposition of the stratum I have named upper boulder clay, will be apparent to any one who studies the question. The fossil fauna and flora found in the stratified beds in Cowden Glen, as well as the flora found at Overtoun, Hillhead, and other places, speak of land comparatively free of ice: then a great physical change succeeds. The land has either been covered by floods of water or fields of ice, and the vegetation has been destroyed and mixed up in the bottom of the stratum, which has partly covered the old surface. If ice has been the cause of the change, it has been in a greatly modified degree to what we find it working in the lower boulder clay. And it would be worth while to see if this modification has not been too great for the results, which we find to have taken place by the deposition of the superincumbent beds to the old land surface.

Previous to the deposition of the lower boulder clay all the land surface above sea level has been removed, and the underlying rock surfaces planed down, polished, and striated by the ice, or rather by the weight of the ice acting upon the moving bed of the glacier formed by the accumulation of the *debris* of the rocks. In testing the glacier origin of the upper bed, this is a test I have looked for in vain. At Overtoun and Hillhead, where the fossiliferous clay had been denuded and the upper bed of boulder clay rested upon the rock, neither polish nor striation were present. In Cowden Glen the upper peat bed bore no trace of being disturbed by a heavy body having passed over it. The three feet of clayey sand marked in the section as overlying the peat bed on its south-west end, north-west side, most likely belongs to the upper bed of boulder clay, as it only had about the same extent as this bed; but allowing it to belong to the stratified beds, it has not the slightest degree of twisting which we would have expected had a heavy body passed over it. And had the upper boulder clay been the result of land ice, these under beds must have been passed over by a very great

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weight. The two bosses of this upper bed which lie in the valley, and are partly superincumbent to the stratified beds, have a magnitude of about, the one 200 yards long, 100 broad, and a depth of 3 to 10 feet; the other one, 100 yards long, probably the same in breadth, and an average depth of five feet—no light weight, if we add that of the ice along with it, to have passed over a soft peat bed and to leave no trace of itself behind. The question arises—Could a glacier, so modified as to pass over a peat bed without disturbing it, be capable of transporting the above material? Or, *vice versa*, Could a glacier, capable of transporting the above, or being so loaded, pass over a peat bed of a few feet in thickness without leaving strong trace of itself behind? It has been suggested by some geologists that the peat bed might have been so frozen that such a result might have taken place. But is this in accordance with the laws of glacier action? At Overtoun the intercalated bed shows no sign of crushing or twisting. At Hillhead, slight signs of crushing were visible. Another notable difference betwixt the two beds is found in the boulders. In the lower bed lying south and south-west from the Beith limestone, from 70 to 80 per cent. of the boulders are limestones from the outcrop and upper beds of that strata, or greenstones from the dykes which intersect the limestone strata. This holds good for one to two miles south and south-west from the outcrop. In the patches of the upper bed laid open in the same locality there was a total absence, or nearly so, of limestone boulders. And in reverse, the bed at Overtoun, lying north-east from Broadstone, contains a calcareous shale of light specific character, found in position at the latter place about half a mile distant. That the ice sheet which deposited the under boulder clay has come from the north, and passed to the south, is proved both by the striations on the rock surfaces and the boulders. If the intercalated beds have been deposited during a partial withdrawal of the ice, and the upper boulder clay a deposit from a return of it, how comes this shale found at Overtoun to have travelled half a mile in a contrary direction to that of the glacier motion? These are queries easily explained, if water is adopted as the agent which has deposited this upper bed, but rather difficult to solve under the ice theory.

In adopting water as the agent to whose presence we owe this upper bed I am not alone in my opinion. All the older geologists look upon the boulder clay as partly a water deposit, and the late

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Mr. Smith, of Jordanhill, who appears to have been intimately acquainted with the upper bed (see "Newer Pliocene Geology," page 133), sets it down as a deposition from combined water and ice. One proof in favour of it being a water deposit is the partial character of its development. It is only found in valleys, as at Cowden Glen, or in little patches around the flanks of bosses of the lower bed. It is of a gravelly nature, such as we might expect the lower bed to be, with part of the fine clay washed out of it. Overlying this upper bed in the north of Ayrshire and surrounding district, we find a gravel bed from a few inches to as many feet thick, and running into mounds of gravel and sand, as at Bogside, Beith, Lochlibo, and other places. At Bogside, Lochlibo, and wherever I have seen them opened, these mounds were stratified. Few of the stones are striated, although I take them to have been washed out of the boulder clay, as they are identical with the small boulders contained in the surrounding bosses of that deposit. Another proof of a post-glacial submergence occurs in large blocks of loosened stones, principally sandstone, found in certain places scattered over the surface of the lower boulder clay near to the outcrop of their parent bed. A bed of scattered blocks was found in a cutting on the Kilmarnock and Crofthead Railway, near to Lugton Inn, Dunlop. They were lying scattered on the top of the clay, as if thrown about by waves of water. Mr. Arch. Geikie, in his "Phenomena of the Glacial Drift of Scotland" (Transactions of this Society, vol. i., part ii., page 33), mentions a hill of red sandstone in the Upper Ward of Lanarkshire "so completely enveloped in its own ruins that the rock of which it is composed can hardly anywhere be seen *in situ;* and yet numerous quarries have been opened on its long moory top, and all the walls of the neighbourhood have been built out of the angular rubbish." By what theory could a glacier be converted into such a powerful quarrying agent? Water, or water and ice combined, could remove rocks, and leave the disintegrated blocks scattered over their paren tbed as here noticed. But wherever ice has taken up blocks of rock, it has uniformly carried them forward in a certain direction, and dropped them at lesser or greater distances from the parent bed. At Lugton Inn the blocks were partly scattered over the surface of the parent bed and partly over a boss of the lower boulder clay lying to the north-east in junction with the rock. The upper beds of the sandstone stood

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considerably higher than the clay, and it was from these top beds where the blocks of angular unstriated sandstone had come.

That a post-glacial submergence has really taken place I have only to refer to the Clyde shell beds overlying the lower boulder clay. And if the remnant of clay containing shells, found near Airdrie, at an elevation of 510 feet above sea level, be equivalent to the Clyde shell beds, then these beds are intercalated with the upper and lower beds of boulder clay, and will thus add to the lengthened period of time which separates the two deposits.

In bringing my opinion about the formation of this upper bed of boulder clay before the Society, in this speculative manner, I have done it more with the intention of drawing closer observation to the upper bed of boulder clay than to give any dogmatic opinion of my own. However, I may state that the opinion has been formed after much observation upon the two deposits, not only upon the different character they hold as clays, but upon the large amount of underlying stratified clay found in the upper bed. How that these pieces of clay, angular and uncrushed, with their fossil contents entire, could have remained so had the upper bed had a common origin with the lower, whose boulders have been ground down, rounded, and scratched, has always been a puzzle. Then, if the mounds of sand and gravel found in the north of Ayrshire and neighbourhood be equivalent with the kames found in the other parts of Scotland, these are deposits subsequent to the upper bed of boulder clay, and the absence of striations on the stones mixed with them, and on the rock surfaces upon which they lie, look rather against their glacial origin.

Whatever the future may decide about the origin of the upper bed of boulder clay, we can now perceive that a long period of time elapsed between the deposits, when the country had been a land surface, with a vegetation not unsimilar to that at present, where the bos, the elk, and the horse roamed and browsed on the Renfrewshire hills.*

* These stratified beds in Cowden Glen have been described by Mr. James Geikie as interglacial, and consequently the two small sections of upper boulder clay as a deposit from land ice. At the time he published his first account of the beds (*Geological Magazine*, vol. v., p. 393) I slightly protested against the latter conclusion. Mr. Geikie has since published two short papers, more strongly reiterating his opinion. (See *Geological Magazine*, vol. vi., p. 73, and vol. vii., p. 53.) The only real difference, as I understand it, between Mr Geikie and myself is, that he takes the upper bed, which overlies the stratified beds in Cowden Glen,

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Section No. 2.

Taken near the centre of beds on the east of the divisional boss of boulder clay.

By Cutting.	Ft.	in.
Sandy loam,	4	6
Peat, or leave bed,	0	10
Mud, with layer of sand,	3	0
Mud,	4	0
Boulder clay,	1	6
Mud,	3	0
Boulder clay,	3	6
Mud,	1	0

By Bore.	Ft.	in.
Mud,	14	3
Brown clay, with stones—borer's term for boulder clay,	6	0
Mud,	11	6
Broken whin—borer's term for water-worn gravel—of rock similar to that of the north side of the valley,	6	0
	59	1

From this section it will be seen that three beds of boulder clay are intercalated with the stratified beds, and if the section had been taken a little nearer the north bank, a fourth bed would have overlapped the sand and mud beds. The beds in the cutting were of no great extent, crossing the mud from the north side, about two-thirds across the valley, and had a breadth—the one of 20 yards, and the other of 45 yards; they thickened as they approached the north bank, while the intercalated mud thinned as it neared the same side, giving the beds in a cross section the appearance of being half dovetailed into one another.

Section No. 3.

Taken in centre of small section of intercalated beds, on the east end of the large rock cutting, and nearly half a mile nearer Neilston Station than the one above.

By Cutting.	Ft.	in.
Gravelly clay, upper boulder clay,	8	0
Mud,	0	11
Boulder clay,	1	2
Mud,	1	0
Boulder clay,	1	10
Mud,	0	11
Boulder clay,	1	3
	15	1

By Bore.	Ft.	in.
Red soft clay—borer's term for Mud,	4	0
Hard boulder clay,	14	0
Fine red clay, with stones and sand,	2	0
	20	0
	15	0
	35	0

and elsewhere in Scotland, to be a deposit from land ice. This I question, and am of opinion, that the evidence bearing upon the subject points more to a water origin than to that of ice. About other matters relating entirely to Cowden Glen, in his two last papers, it will be seen that a wide difference exists between us. Mr. Geikie ignores the slips altogether, and leaves the readers of the *Magazine* under the impression that the large mass of boulder clay, shown in No. 1 woodcut (*Geological Magazine*, vol. v., p. 393), as overlying the stratified beds, is upper boulder clay, while it has since been clearly proven to have been a series of slips.

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Further comment on this bed would be useless. It may be as well to state that no boulder clay was intercalated with the stratified beds lying on the west of the divisional boss of boulder clay. The glen here widens into a valley form, and the hillside on the north falls back gradually at a slope of about 12°; while on the east of this boss the north bank is a bold escarpment of nearly perpendicular rock, 80 feet high.

JOURNAL OF BORES.

These bores are copied *verbatim* from the borer's book, permission being kindly granted by Mr. Strain, C.E. They were taken in the section of cutting on the east of the divisional boss of boulder clay at regular distances of 100 feet apart; the first commencing on the eastern end near to the glaciated rock, and the seventh beneath the bridge at the western extremity of the mud beds in this section. No. 8 bore was taken in the section marked No. 3. They were all taken in the bottom of the cutting, and thus show the nature of the beds lying below the level of the railway as far as bores can do so. Nos. 2 and 3 are of importance in corroborating what had been observed in removing the beds above the railway level, that sheets of boulder clay had run off the northern hillside into the lake below during the period when it was being silted up:—

Bore No. 1.

	Ft.	in.
Soft mud,	8	0
Broken whin,	4	3
	12	3

Bore No. 2.

Soft mud,	14	3
Clay, mixed with stones,	6	0
Soft mud,	11	4
Broken whin,	6	0
	37	7

Bore No. 3.

Soft mud,	6	0
Clay, with stones,	6	0
Mud,	9	0
Mud,	17	0
Broken whin,	4	6
	42	6

Bore No. 4.

Soft mud,	30	0
Soft mud,	7	6
	37	6

Bore No. 5.

Blank.

Bore No. 6.

	Ft.	in.
Mud,	9	6
Red till, with stones,	22	0
	31	6

Bore No. 7.

Red till, with stones,	26	0
Whinstone,	1	6
	27	6

Bore No. 8.

Red soft clay, with stones,	4	0
Hard boulder-clay, with stones,	14	0
Fine clay, mixed with sand and stones,	2	0
	20	0

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NOTE.—Samples of the beds were preserved by Mr. Strain, and kindly shown to me, when copying the bores. The mud is identical in character with that in the railway cutting, but some samples taken from near the bottom of the bed have more the character of a fine brown-coloured brick clay. The six feet of stony clay in Nos. 2 and 3 bores has a brownish colour, and strikingly identical to the "red till" in Nos. 6 and 7 bores. The clay marked "red till" here by the borer is the *boss* of lower boulder clay which divides the two sections of laminated beds. Its colour, when first laid open, was dark, with a slight tinge of brown, but exposure to the atmosphere heightens the tinge, as it does in most boulder clays. The bed marked "broken whin" in the first bores is water-worn gravel, identical with a bed that rose from under the soft beds in the northern bank, and the "whinstone" in No. 7 is very likely a boulder; in fact, it is almost certain to be so, as from the formation of the valley the rock surface will lie at a much greater depth at this place.

III. *The* POST-TERTIARY FOSSILIFEROUS BEDS OF SCOTLAND. By THE REV. HENRY W. CROSSKEY, F.G.S., AND MR. DAVID ROBERTSON, F.G.S.

(Continued from Part II., page 341.)

XII.—GARVEL PARK NEW DOCK, GREENOCK.

CONSIDERABLE discussion has been occasioned by the unusual appearance of this deposit. It has been regarded as doubtful whether the animals, whose remains are embedded in it, lived and died where they are now found, or whether this mass of fossiliferous clay might not have been removed from its original position, and transported thither either by the labour of man, or by some other agency, such as ice action.

The Dock, which is now in course of construction, runs nearly parallel with the Clyde, and cuts through a slightly-inclined bank of compact boulder clay, about sixty yards from the shore.

The bottom of the section is forty feet beneath the surface. The first ten or fifteen feet are crowded with large boulders, many of them striated on one or more sides. Towards the bottom boulders of large size are fewer, one only being seen here and there; but the clay is closely packed with small pebbles, few of them exceeding an inch in diameter. The great majority of the larger boulders throughout are sandstones of the neighbourhood; the remainder being of quartz, mica-schist, etc., from the Argyleshire mountains to the north-west.

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These latter blocks, derived from a distance, seem, in general, considerably water-worn, and not unfrequently show much cross striation.

The boulder clay is of the usual stiff consistence, and so great is the difficulty of working it that blasting with gunpowder has been tried, without very promising results. The deep section of the dock is about five hundred feet in length, and in that distance the colour of the clay varies a good deal at different places; the junction of grey and reddish-brown clays at some points being very decidedly marked, both vertically and horizontally. Besides the alternate layers of different coloured clays, the red clay at one place, in the form of an obtuse inverted cone, reaches nearly to the bottom of the section, and thus accounts for the irregular position of the red and grey clays, as described in the journal of the bores.*

The colour of the reddish till is, no doubt, due to a large admixture of the soft old red sandstone on this portion of the coast.

A sample of the red till, taken from a depth of 14 feet, consisted of 76 per cent. fine mud; 10 per cent. sand; 14 per cent. gravel, or small pebbles.

A sample of the grey till, taken from a depth of 30 feet, consisted of 56 per cent. fine mud; 9 per cent. sand; 35 per cent. small gravel.

In the upper red till, the West Highland rocks entering into its composition constitute less than one-third; while in the lower division of the grey till, at the depth of thirty feet, they form more than the half of the bulk of the washing.

The bores made preparatory to the construction of the dock, extending over a radius of about six hundred feet, show that the different coloured clays overlie each other, subject to many irregularities.

* By the term "*Till*," throughout these descriptions of the borings, is meant the special deposit, which is termed in this series of papers, "boulder clay." It is important that this should be carefully understood, since "*Till*" is the term frequently used to denote the whole series of glacial deposits, and indiscriminately applied to the lower boulder clay and the upper laminated clay. In these pages we restrict the term *boulder* clay to the older deposit of the Scotch glacial series containing striated blocks, and throughout the beds of the Clyde district, except in a few special cases of a peculiar character, underlying the shell clay.

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JOURNAL OF BORES AT GARVEL PARK.

	Ft.	In.	Ft.	In.
No. 1.				
Soil,	1	0		
Light till,	29	0		
			30	0
No. 2.				
Soil and sand,	2	6		
Light till,	38	6		
			41	0
No. 3.				
Soil,	1	0		
Sand,	2	0		
Sand and gravel,	5	0		
Light till,	32	0		
			40	0
No. 4.				
Soil,	1	0		
Gravel,	1	6		
Light till,	5	6		
Red till,	4	0		
Sandstone rock,	3	0		
			15	0
No. 5 (in River).				
Sand,	2	0		
Red till and stones,	6	0		
Sandstone rock,	1	0		
			9	0
No. 6 (in River).				
Dark sand,	3	0		
Light till,	3	0		
Red till,	11	0		
			17	0
No. 7 (in River).				
Dark sand and shells,	3	6		
Light till,	8	0		
Mud	1	6		
Red till,	6	0		
			19	0
No. 8 (in River).				
Sand and shells,	18	0		
Red till,	2	0		
			20	0
No. 9 (in River).				
Light till,	4	0		
Red do.,	15	0		
			19	0
No. 10 (in River).				
Sand and shells,	7	6		
Light till,	17	6		
			25	0
No. 11 (in River).				
Sand,	9	0		
Light till,	11	6		
			20	6

	Ft.	In.	Ft.	In.
No 12 (in River).				
Sand,	27	0		
Light till,	9	0		
			36	0
No. 13 (in River).				
Light till,	20	0		
			20	0
No. 14 (in River).				
Light till,	24	0		
			24	0
No. 15 in (River).				
Dark sandy till,	6	0		
Light till,	14	0		
			20	0
No. 16 (in River).				
Red till,	7	6		
Sandstone rock,	2	6		
			10	0
No. 17 (in River).				
Sand and shells,	4	0		
Dark sandy till,	7	0		
Red till,	9	0		
			20	0
No. 18 (in River).				
Dark sandy till,	6	0		
Red till,	4	0		
Sandstone rock,	1	0		
			11	0
No. 19 (in River).				
Red till,	6	0		
Light till,	13	0		
Mud (firm),	6	6		
			25	6
No. 20, or No. A.				
Soil,	1	0		
Silt and shells,	6	6		
Light till,	26	6		
			34	0
No 21, or No. B.				
Soil,	1	0		
Light till,	34	0		
			35	0
No. 22, or No. C. (in River).				
Light till,	30			
			30	0
No. 23, or No. D. (in River).				
Light till,	30	0		
			30	0
No. 24. or No. E. (in River).				
Light till,	30	0		
			30	0

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	Ft.	In.	Ft.	In.
No. 25, or No. F.				
Soil,	1	0		
Gravel,	3	0		
Light till,	27	0		
			31	0
No. 26.				
Soil,	1	0		
Light till,	33	0		
Red do.,	3	0		
Light do.,	3	0		
			40	0
No. 27.				
Soil,	1	0		
Light till,	1	6		
Sandstone block,	1	0		
Light till,	36	6		
			40	0
No. 28.				
Soil,	1	0		
Light till,	3	0		
Red do.,	15	6		
Hard white sandstone,	0	7		
			20	1
No. 29.				
Red till and stones,	4	0		
Light do. do.,	13	0		
			17	0
No. 30.				
Red till and stones,	10	6		
Light do. do.,	13	8		
Red do. do.,	5	2		
Red sandstone	3	2		
			32	6
No. 31.				
Red till and stones,	8	3		
Light do. do.,	9	0		
Red sandstone,	6	1		
			23	4
No. 32.				
Light till,	14	7		
Fire-clay,	1	9		
Red sandstone (soft),	4	7		
Do. do. (hard),	1	5		
			22	4
No. 33.				
Soil,	1	0		
Light till,	34	5		
Do. do., with blocks,	6	1		
			41	6
No 34.				
Soil,	1	0		
Light till and stones,	6	4		
Sandstone block,	1	6		
Light till and stones,	2	6		
Sandstone block,	2	3		
Light till and stones,	24	4		
White sandstone,	0	1		
			38	0
No. 35, Trial Pit.				
Soil,	1	0		
Yellow clay,	7	6		
Grey till and stones,	13	6		
Red, do. do.,	3	0		
Grey till,	2	0		
White sandstone,	0	11		
			27	11
No. 4a.				
Soil,	1	0		
Yellow clay,	5	6		
Grey till,	18	0		
Red sandstone,	3	6		
			28	0
No. 5a.				
Soil,	0	9		
Yellow clay,	4	6		
Grey till,	8	3		
Red till,	3	3		
Red sandstone,	3	2		
			19	11
No. 6a.				
Red till and stones,	3	9		
Soft white sandstone,	1	6		
			5	3
No. 7a.				
Sand and stones,	1	6		
Red till and stones,	4	0		
Darker do. do.,	6	0		
			11	6
No. 8a.				
Light grey till,	1	0		
Fine red till,	6	6		
			7	6

Looking at these forty bores, and confining ourselves to the clays only, which vary from nine to thirty-eight feet in thickness —in nineteen of these, what is termed light till *(grey unstratified clay)* is only met with. In six bores, what is termed red till *(reddish unstratified clay)* is only met with. In other six both

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occur, and the light-coloured till overlies the red. In three the red overlies the light, while in the remaining six the clays alternate variously. For example, taking them in the ascending order, in one bore, No. 26, light till, three feet; red till, three feet; light till, thirty-three feet. In another, No. 30, red till, five feet; light till, thirteen feet; red till, ten feet.

Three of the bores, lying between the dock and the highway, have the addition of what is termed yellow clay. Taking them in the same order as above, in No. 35, light till, two feet; red till, three feet; light till, thirteen feet; yellow till, seven feet.

In another, No. 4, light till, eighteen feet; yellow clay, five feet. Again, in No. 5a, red till, three feet; grey till, five feet; yellow till, four feet.

In all these bores, some of which extend two hundred feet beyond low water, the same varieties of boulder clay have been met with in varying proportions.

In bore No. 8, sixty yards beyond low water, eighteen feet of sand and shells overlie the red till; but we regret that we cannot learn whether the shells belong to the glacial or recent period.

About the same distance beyond low water, No. 12, twenty-seven feet of sand overlies light till; another bore, about half-way between this and low water, No. 13, gives twenty feet light till.

The manner in which these different coloured clays alternate with each other is full of interest, and worthy of careful study.

The fossiliferous clay lies in a trough or oblong hollow in the boulder clay crossing the longitudinal section of the dock, and shallowing at both ends. On the south it terminates near the surface about two hundred yards west of Garvel Park House, and on the north, at the embankment near the surface, close to the Clyde.

The length of the trough is about three hundred feet, its breadth twenty-four feet, and its depth, near the middle, fourteen feet. This trough is filled with a remarkable fossiliferous clay, crowded with post-tertiary shells and other marine organisms, which, like those found in other "Clyde beds," are of arctic type. It is this deposit which, in some of its aspects, has perplexed so many observers, and on which, after careful scrutiny, we venture to submit the following observations:—

The chief objections that suggest themselves to the natural character of the deposit are—(1), the disorderly manner in which

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the shells are distributed, and (2), the soft, loose state of the clay in which they are embedded, and which certainly bears a striking resemblance to material that has been roughly tumbled in rather than regularly deposited.

We think, however, the facts of the case not unfavourable to the conclusion that these shells lived and died where they are now found.

With regard to the apparent disorder in which they lay, it is well known that where mollusca congregate, dead shells often preponderate largely over the living, and that a great number in this deposit accumulated as dead shells is evident from the numerous valves having their internal surfaces grown over with marine organisms. Although, on a cursory view, they look as if tossed about, and promiscuously heaped together, yet, on closer examination, this irregular appearance seems to arise chiefly from the presence of so many large valves of dead shells, and, taking the general arrangement, they alternate very distinctly in layers.

The soft, loose state of the clay is perhaps a more difficult problem, but the following suggestion may help to explain it. This fossiliferous deposit unquestionably rests in a hollow or trough formed in the boulder clay. The open shelly clay of the deposit would take in more water from the surface than the stiff compact clay on which it reposes could withdraw, and an excess of water, accordingly, would be retained in the trough. This being cut through at the deepest part by the excavation of the dock, and the superfluous moisture to some extent drained off, would naturally bring the deposit much to its existing state.

Similar cases are by no means uncommon. In uncultivated moorlands, our footing is often insecure, owing to impermeable hollows filled with silt, or other porous material, and grown over with turf, which may remain in this state indefinitely, while the surface continues to supply the water, and the basin to retain it. Such conditions are well known to agriculturists, whose skill is exerted in discovering how they can best draw off the imprisoned water which impedes the fertility of their lands over particular areas.

We may add that the boulder clay immediately under the laminated clay at the botton of the trough is softer for fifteen or twenty inches downwards than at a greater depth, doubtless owing to contact with the moister clay above. There are facts,

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moreover, which it is difficult to reconcile with any mere drifting agencies.

(1.) The large boulders embedded in the shelly deposit. Many of these, before they were blasted—and we refer only to those which had marine organisms adhering to them—could not be less than half a ton in weight.

Such boulders could not have been scooped up by any dredging machine, nor brought from any other source without great labour, and it is very unlikely that such large and unwieldy materials would have been selected, and brought for some distance for levelling purposes by man during any previous operations. Indeed the contractors inform us, that with all their improved appliances they should never think of removing one of these large blocks without blasting, and not one of these when uncovered was seen with the slightest mark of a mallet, or bore of a blast upon it.

(2.) Had the fossiliferous material been dug up from one place and carried to another by human agency, unmistakeable tool marks, cuts and indentations of pike and shovel, would have been visible on the shells in their crowded condition; but not a single mark of this kind has been found.

(3.) Although the great mass of the shelly deposit lies in some apparent disorder, the under portions of it are distinctly laminated. Resting on the boulder clay there is an unevenly thin bed of reddish-brown clay, made up of very fine layers. Overlying this is a layer of whitish clay, about six inches thick, which is again covered by a layer of light grey clay, about one inch thick. These layers can be traced over the bed and up both sides of the trough, and it is impossible that sediment washed down through the loose materials above, as has been supposed, could have been accumulated in this manner. Again, had the layers been the immediate washings of the upper material, they would have been similar in colour and composition; but all three differed largely from the overlying clays, as well as amongst themselves in colour, constitution, and fossil contents.

The thin light grey layer lying between the whitish six-inch layer and coarser shell clay above, contains one polyzoon *(Idmonea)*, far more abundantly than we have found it elsewhere in the section. In this thin layer also occur the asbestos-like fibres of the shell of the common mussel *(Mytilus edulis)*, of which we have not found a vestige in the overlying clays. The six-inch

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stratum of whitish clay is, when dry, of an extremely friable character, and very like a stratum of clay met with in some of the Paisley brick-fields, and at Jordanhill, in the same relative position, and the reddish-brown clay underlying this corresponds with the thinly-laminated clays frequently found at the base of the fossiliferous clays of the Clyde district. Further, these underlying strata all contain organisms of marine and arctic character, without the least admixture of those decided brackish-water forms so common in the present neighbouring lagoons of the Clyde.

(4.) At the south end of the hollow, lying between the shell clay and the upper mould, a bed of brown clay is disclosed, about two feet in thickness, which Mr. Robert Craig, of Beith, and Mr. Kirk, contractor of the works (who examined it along with us), agreed in concluding has never been disturbed since it was deposited.

As all these circumstances are incompatible with the supposition that the deposit has been filled in by human agency, they are equally so with the theory of its having been transported from some neighbouring locality by the action of ice. This (as Mr. John Young has pointed out) in no way agrees with the condition of the contained fossils, which bear no trace of having been rolled and crushed, as they would infallibly have been from such a cause. The other facts we have adduced seem no less conclusive against this hypothesis.

Traces of a thin irregular bed of small shells have been seen near the surface along the south-east side of the dock; and about one hundred yards from this, in an easterly direction, another shelly deposit, belonging to the same series, has been exposed on the side of a sandstone quarry, where the shells and other organisms, though fewer in number and variety of species, and different in their proportions, are similar in character to those we have described. Quite recently, yet another shell bed, also of arctic type, has been brought to light in making the channel way to the west end of the dock, rather below half-tide. That these beds at one time were all connected is highly probable, but there appears no evidence that any of them were ever covered by the boulder clay.

We mention this because at first sight the deposit in the hollow seems to dip under the boulder clay, but on further examination it is clearly seen to thin out to the surface.

The whole Frith of Clyde, on both sides, is patched with beds of laminated fossiliferous clay, which, doubtless, at one time covered

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the bottom from side to side, and reached the various heights on which we find their remains above the level of the sea. The whole deposit has evidently suffered much since it was first laid down from currents, change of level, and other causes.

The clays are generally found cut away between low tide and high water mark, where the abrading power of the water is greatest. Examples may be seen at Langbank, Helensburgh, Roseneath, Fairlie, Cumbrae, &c. In these localities the truncated edges of the fossiliferous clays are exposed to view here and there in the more sheltered hollows along the tidal belt.

The trough that we find at Cartsdyke has, doubtless, been separated from the deposit existing close by, near low water mark, by the agencies determining the distribution of the beds through the whole frith.

The Cartsdyke deposit is remarkable, not only for its puzzling appearance, but for the great abundance and diversity of organisms found crowded within its narrow limits.

The dry fossiliferous clay consists of 76 per cent. fine mud; 19 per cent. fine and coarse sand; 5 per cent. gravel and shell *debris*.

The gravel, chiefly sandstones of the neighbourhood, the remainder being quartz, mica-schist, &c., the greater portion less or more water-worn and striated.

In our list of mollusca sixty-one species and seven varieties have been identified. The two prevailing shells are *Pecten Islandicus* and *Mytilus modiolus*, but perhaps the shell of most geological interest in this deposit is *Pecten maximus*, as it has been considered doubtful whether it lived at the same time in the Clyde beds with *Pecten Islandicus* or at a subsequent period.

There is one circumstance connected with this shell which may be mentioned. That is, we have never seen nor heard of Balani being attached to *Pecten maximus* in the Clyde beds; yet, in the same beds *Balani* are common on *Pecten Islandicus*, and as *B. porcatus* and *B. crenatus* do not in any way seem fastidious in their choice of attachment, whether to a stone or shell, we may reasonably infer that most of the shells of *Pecten maximus*, found in our Clyde beds, were not cohabitants with *Pecten Islandicus*. It may be further remarked that *Pecten maximus* is not uncommon in the Frith of Clyde, and its valves abound in our silts and raised beaches, and many specimens, really belonging to younger beds, may have been accidentally mingled with the older fossiliferous clays beneath.

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From such mixtures, we fear, records of glacial shells from the Clyde have been too often augmented.

The specimen of *Pecten maximus* from Cartsdyke, although one valve only was met with, is of considerable interest, as the deposit is beyond the influence of the tide; whereas the other beds in which they have been found in the west of Scotland, Fairlie, Kyles of Bute, and Ettrick Bay, are all between high and low water mark, and ever since these beds were discovered they have been zealously dug over in search of fossil remains, and re-arranged again and again by every storm and tide. Under such circumstances all attempts to determine the true position of shells that are common to both the recent and the older clays are quite unreliable, and conclusions drawn from such data must at all times be highly questionable.

PISCES.

A few small vertebræ, and otolites.	Rare, undetermined. The vertebræ were from a fish probably not exceeding six inches in length. The otolite seemed to be from a fish about the size of a herring.

CONCHIFERA.

Anomia ephippium, Linn.	Common; small.
——————— var. *aculeata*.	Moderately common.
——————— var. *squamula*.	Moderately rare.
Pecten maximus, Linn.	One valve.
———*Islandicus*, Müller.	Common; many with valves together.
Mytilus modiolus, Linn.	Common, do. do.
———- *edulis*, Linn.	Fibres only of shell structure.
Modiolaria nigra, Gray.	Rare in Clyde beds.
Nucula tenuis, Montagu.	Moderately common.
Leda pernula, Müller.	Common.
——————var. *mucilenta*, Steenst.	Moderately common.
———*pygmæa*, var. *lenticula*, Müller.	Moderately common.
Axinus flexuosus, var., Gouldii.	Common.
Cardium fasciatum, Montagu.	Moderately common.
——— - *edule*, Linn.	One fragment.
——————*exiguum*, Gmel.	Moderately common.
Cyprina Islandica, Linn.	Moderately common.
Astarte sulcata, Da Costa.	Common.
———- *compressa*, Mont.	Common.
——————————var. *globosa*.	Rare.
Tellina calcarea, Chemnitz.	Moderately common; rather small in size.
Scrobicularia alba, Wood.	Moderately common.

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Mya truncata, Linn.	Moderately common; impression of the siphon was found in the clay.
Saxicava rugosa, Linn.	Moderately common; full average size.
——————— var. *arctica*, Linn.	Moderately common.
Pholas crispata, Linn.	Fragments; moderately rare.

GASTEROPODA.

Chiton marmoreus, Fabr.	Plates; common, and large.
——— *ruber*, Linn.	Moderately rare.
——— *cinereus*, Linn.	Common.
Tectura virginea, Muller.	Common, and large.
Puncturella Noachina, Linn.	Moderately common.
Trochus helicinus, Fabr.	Moderately common.
——— *Grœnlandicus*, Chem.	Common, and large
——— *tumidus*, Chem.	Moderately common, & in fine condition
——— *cinerarius*, Linn.	Moderately rare.
Lacuna divaricata, Fabr.	Mature individuals, moderately common; young, abundant.
——— *puteolus*, Turt.	Moderately rare.
Littorina littorea, Linn.	Moderately common.
——————— *rudis*, Maton.	Moderately rare.
——— var. *saxatilis*.	Rare.
——— *limata*, Loven.	Moderately common.
——————— *obtusata*, Linn.	Moderately common.
Rissoa parva, Adams.	Moderately rare.
——— var. *interrupta*.	Very common.
——— *striata*, Adams.	Very common.
——————— var. *arctica*.	Moderately rare.
Skenea planorbis, Fabr.	Common.
Homalogyra atomus, Philippi.	Common.
Odostomia Lukisi, Jeffrey.	Rare; new to Clyde beds.
——————— *unidentata*, Montagu.	Moderately common.
Natica Grœnlandica, Beck.	Moderately common.
——— *affinis*. Gmel.	Moderately common.
Velutina lævigata, Linn.	Moderately common.
——— *undata*, Smith.	Rare.
Trichotropis borealis, Brod.	Moderately common, & in fine condition
Buccinum undatum, Linn.	Moderately common.
Trophon clathraus, Linn.	
——— ——— ——— *var Gunneri*.	Moderately common.
——— *truncatus*, Ström.	Very common.
Fusus antiquus, Linn.	Rare.
Pleurotoma violacea, Migh. and Ad.	Moderately common.
——————— *turricula*, Mont.	Moderately rare.
Cylichna alba, Brown.	Moderately common.
Utriculus hyalinus, Turt.	Moderately common.
——— *obtusus*, Mont.	Rare.

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POLYZOA.

Caberea Ellisii, Flem.	Moderately rare.
Membranipora Flemingii, Busk.	Moderately common.
Lepralia Peachii, Johnst.	Moderately common.
—— —— *concinna*, Busk.	Moderately rare.
———— *annulata*, Fabr.	Moderately common.
———— *hyalina*, Linn.	Moderately common.
———— *verrucosa*, Esper.	Moderately rare.
—— —— *crystallina*, Norman.	Moderately common.
———— *cruenta*, Norman.	Moderately common.
———— *tubulosa*, Norman.	Moderately common.
Tubulipora patina, Linn.	Moderately rare.
Idmonea fenestrata, Busk.	Common. The only other in which this species has been met with in Scotland is on the opposite side of the Frith.
Crisia eburnea, Linn.	Moderately common.

CRUSTACEA.

Claws and plates.	Various; not determined.

OSTRACODA.

Thirty-five species.	

CIRRIPEDIA.

Balanus crenatus, Brug.	Common.
———— *porcatus*, Da Costa.	Common.
———— *Hameri*, Ascan.	Rare. It occurs in the Lochgilp beds (Argyllshire), and in a cutting at Old Mains sparingly (Renfrewshire). In Uddevalla deposits (Sweden), it is the prevailing cirriped, and of great size, and contributes largely to the bulk of the deposit.
Verruca Strömia, Müll.	Very common; and great numbers still attached to the objects they had selected in life, which we do not commonly find with this species in the fossil state.

ANNELIDA.

Filograna implexa, Berk.	So far as we know, this species is new to the post-tertiary clays. It is not rare in this deposit: two or three specimens have been obtained, and the *debris* of the broken up fascicles is of frequent occurrence amongst the clay.
Spirorbis spirillum, Linn.	Common.
Serpula vermicularis, Ellis.	Common on shells and stones.

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ECHINODERMATA.

Echinus Dröbachiensis, Müll.	Common. Some of the plates have one or two of the rows, having six pairs of pores in the row, instead of the normal number, five; but there are other plates containing six pairs of pores in all the rows. This, we think, may imply a further deviation of the occasional pair, instead of five, rather than a specific difference.
——— *sphæra*, Müll.	Moderately common.
Spatangidæ.	One spine.
Ophiura texturata, Lam.	Plates.
——— *albida*, Forbes.	Ray plate.
Ophiocoma bellis, Link.	Ray and disk plates.
Sipunculus Bernhardus (?), Forbes.	Moderately common.

FORAMINIFERA.

Cornuspira foliacea, Philippi.	Moderately common.
Biloculina ringens, D'Orb.	Moderately common.
Triloculina tricarinata, D'Orb.	Rare.
——— — *oblonga*, Mont.	Rare.
Quinqueloculina agglutinans, H. B. Brady.	Moderately common.
——————— *seminulum*, Linn.	Common.
——————— *subrotunda*, Mont.	Common.
Lagena sulcata, W & J.	Common.
——— *lævis*, Mont.	Rare.
———·——— var.	Rare.
——— *striata*, Mont.	Rare; very fine.
——— *apiculata*, H. B. Brady.	Moderately common.
— — *distoma*, P. & J.	Moderately rare.
——— —·· var.	Rare.
——— *gracillima* var. Seg.	Rare.
——— *globosa*, Mont.	Common.
Dentalina communis, D'Orb.	Rare.
Cristellaria rotula, D'Orb.	Moderately common.
Polymorphina compressa, D'Orb.	Rare.
———·——— *lactea* var. *oblonga*.	Rare.
——————·——— *communis*.	Rare.
Verneuilina polystropha, Reuss.	Common.
Bulimina marginata, D'Orb.	Rare.
Truncatulina lobatula, D'Orb.	Common.
Patellina corrugata, Will.	Rare.
Nonionina depressula, W. & J.	Moderately rare.

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SPONGES.

Cliona celata, Grant. Common.

ALGÆ.

Melobesia polymorpha, Linn. Common on stones and shells.

INORGANIC PRODUCTIONS.

In company with Mr. S. B. Murdoch we found a valve of *Pecten Islandicus*, having a greenish coloured patch spreading over the inner surface of the shell. On examination this was found to be made up of small points of iron pyrites, some of which may be observed extending into small branch-like processes. In the Gault we find both Ostracoda and Foraminifera, having their cavities filled with iron pyrites. Mr. J. Wallace Young, in a paper contributed to our Proceedings, mentions the presence of iron pyrites in drift-wood found in post-tertiary sands. Since writing the above we have met with iron pyrites on the inner surface of shells in estuary clay from Cardiff New Docks. At a depth of eight feet, and forty feet beneath the surface, valves of the small ostracoda are numerously filled with it; but at the depth of fifteen, twenty, and thirty feet, slight traces of it only can be seen.

We have to acknowledge our obligations to Mr. J. Gwyn Jeffreys, to Mr. H. B. Brady, to the Rev. A. M. Norman, for their assistance in verifying doubtful specimens catalogued, and to Mr. Kirk, contractor of the works, and his assistants, for their kindness in furthering our inquiries and furnishing us with information regarding the bores and excavations.

IV. *On the* Boulders *found in Cuttings on the* Beith Branch Railway, *considered in relation to their parent rock; with remarks on the local character of the* Boulder Clay. By Mr. Robert Craig, Langside, Beith, Corresponding Member.

(Read February 2, 1871.)

In making the branch railway from Beith to the Crofthead extension line at Waterland, Dunlop, various sections of boulder clay were laid open. This line (now in course of formation) runs nearly south-east from Beith, but changes, as it reaches Waterland, to direct east. The striations upon the glaciated rock-surfaces in the district have a general compass bearing of nearly north-east by east to south-west by west—the line accordingly at its western

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terminus intersecting the striations almost at right angles. In examining the cuttings as they were excavated, and perceiving that the boulders of one cutting did not exactly correspond with those of another, although no great distance apart, it occurred to me that it might be interesting to note down the different varieties of boulders found, principally in relation to the parent rock, from which they have had their source; and in order to appreciate the facilities afforded in this respect, it may not be out of place to give a short vidimus of the petrography of the locality lying to the north-east of the cuttings.

The railway extends along the southern boundary of the Gleniffer range, which commences at Cappelie, Renfrewshire, and running nearly east and west, terminates about half a mile to the west of Beith. Its average breadth is about four miles, and although apparently an independent range, it is connected with the trap hills which extend from Neilston, by Fenwick and Strathaven, on the one hand, and on the other with the range which runs from Erskine to Ardrossan. The rock composition of these traps consists of porphyrites, melaphyres, anamesites, felspathic tuffs, volcanic ash, along with dolerites, and diorites. The porphyrites, which form the principal rock of the group, differ in texture at different parts of the range, thus enabling the geologist to localise the source of the boulders with an exactitude not always attainable. Commencing on the western end, we find around Beith a porphyrite common to the western half of the range. This variety, which is found in many different localities, and is easily recognised, contains round crystals of earthy felspar, in colour from straw yellow to dun white. On the very western end of the range, lying in patches among the bosses of this variety, is found a kind of porphyrite, or dolerite tuff, containing bombs of both. It has a surface of about four square miles, and is largely developed about the Hill-of-Beith. Another easily distinguished variety is that which is found at Cuffhill, Beith. It has a surface of about one square mile, with a few outliers, and is a porphyrite, partly fissile, with crystals of reddish or brown felspar. The other local variety is that peculiar porphyrite found at the Gleniffer end of the range. It occupies a plateau from Cappelie, Neilston, to Tower, Lochwinnoch, with a small tongue running as far south as Shitterflat, Beith. It has thus an area of 16 square miles, and consists of a clay base with square, or lozenge-shaped

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crystals of felspar, of limey whiteness. The dolerites occur in dykes throughout the range, and the melaphyres, anamesites, etc., are found in beds, especially on the northern slope of the hills, near their western termination. The carboniferous strata crop out all along the southern boundary of the trap, in a line north of, and parallel to, the railway, and distant from it about one mile. All the carboniferous boulders are from this source, with the exception of those found in the station cutting at Beith.

The following table gives the per centage of the different boulders found in the various cuttings, and it shows the changes which are observable in proceeding from west to east across the line of glacial action; the change always following that of the rocks lying to the north-east of the cutting. In giving the figures the fractions are withheld, as in most cases the fractional figures were large, and would have only encumbered the table, as no possible counting of boulders in the boulder clay could give them correct to a fraction. The nomenclature is that adopted by the Geological Survey in their catalogue of the rock-specimens of Ayrshire and Renfrewshire. Six inches was the lowest diameter of boulders admitted, with the exception of one of Old Red Sandstone, which was admitted at four inches:—

Names of Cuttings.	Trap Rocks.										Carboniferous Rocks.			Erratics from a Distance.	
	Porphyrites—*Local.*														
	Common.	Hill-of-Beith.	Cuffhill.	Gleniffer.	Amygdaloidal.	Unknown.	Melaphires.	Dolerites.	Anamesites.	Basalt.	Limestones.	Ironstones.	Sandstones.	Old Red Sandstone.	Metamorphic.
Station, Beith,	15	25	..	..	3	7	7	19	..	..	4	3	12	2	2
Mannernheads,	8	8	..	..	..	10	19	23	..	..	8	2	10	7	3
Bridgehouse,	16	20	..	..	..	2	2	9	..	..	27	12	7	..	2
Windyhouse,	6	3	1	..	..	2	10	13	2	5	31	6	12	4	2
Bar, ...	11	..	5	..	3	..	..	15	2	2	28	2	21	5	3
Thirdpart, ..	7	..	..	2	..	2	5	9	..	..	24	2	15	18	10
Highgate, ..	19	..	..	6	2	3	6	10	2	1	16	1	14	8	7
West Waterland,	9	..	..	6	..	..	..	12	4	4	30	5	16	7	4

Note.—The system pursued in counting the boulders was to examine 300 to 400 in each cutting, having a book ruled for the purpose, and noting down each species of boulder in its proper column when examined, and then finding the per centage. This system produces a large number of fractions, which I have thrown off in compiling the table, and given only the whole numbers, for the reason above mentioned.

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From the above it will be seen that the Hill-of-Beith variety extends no further east than Windyhouse, and here it has fallen to 3 per cent., against 25, in the station cutting, and 20 at Bridgehouse. This quite agrees with its position in the range, its centre of greatest development being found from the villages of Beith to Boghall, and parallel to this line are found the corresponding boulders. In Windyhouse cutting, Cuffhill porphyrite first appears, but only as one per cent. At Bar, about three-fourths of a mile to the east, it rises to six per cent., and disappears, not being found in any of the cuttings east of this. This agrees exactly with its position in the hill. From Lochshill, its first appearance on the west, to the escarpment which terminates Cuffhill, its final disappearance on the east, the length will scarcely be one mile, lying parallel to that part of the railway, from Windyhouse to Bar, and only in this parallel line were boulders of this variety found. At Bar the Glenniffer variety was first met with, but only as one in 300; half-a-mile further east at Third-part it was two per cent., and about half-a-mile in an east direction, at Highgate, it rises to six per cent., and at West Waterland, one and a half miles east of the latter, it was found in the same per centage. As in other cases it is the same here, this part of the railway running parallel to that part of the range composed of this variety. These porphyrites, marked in the table as "unknown," do not belong to the locality, as far as my observation goes; although a number of them may belong to the common variety, but more highly indurated than what is generally found in the range, still many of them appear to have a base more serpentinous than any known traps in the district, and are most likely from a distance.

The dolerites were all traceable to local dykes, seven of which intersect the strata north-east from the railway on its western end, and within a distance of two miles from it; these all run in a direction from north-west to south-east, and are intersected by the railway as it proceeds east. The dolerites are highest in the cuttings on the west end of the line, and the same may be said of the melaphyres, which are highest developed along the north-western slope of the range, being found interbedded with the porphyrites, as in Roebank Glen, and are found highest on the west end of the line. The anamesites, diorites, and basalts have a small exposed surface in the range, and figure accordingly in the cuttings.

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An analysis of the carboniferous boulders gives the same results. In the west-end cuttings the limestones are few compared to those in the cuttings which run parallel to the large exposed surface of limestone from Bridgehouse to Waterland. In the station cutting at Beith only four per cent. of limestone boulders was found, and these were all from the Lochwinnoch valley. Here the station lies to the north of the out-crop of the carboniferous strata, which constitute the Beith limestones, and which differ considerably from that which crops out along the northern base of the trap range. At Manneraheads cutting the carboniferous strata extend across to the north of the line of railway, and crop out about two hundred yards from it. The exposed surface, therefore, is not great, and the carboniferous boulders may still be considered small, being four per cent. of the whole. After passing Bridgehouse, the carboniferous becomes the surface strata north of the line to a large extent, and the consequence is a large increase in boulders from that group. Bridgehouse gives forty-six, Windyhouse forty-nine, Bar fifty-one per cent. of the whole boulders. At Highgate they fall to thirty-one per cent., and the porphyrites rise to thirty per cent., from eleven, the per centage in which they are found in the cutting at Thirdpart, to the west of Highgate. Here the railway is intersected by a boss of trap, called Greehill, which passes to the north of the line, cutting out a considerable area of carboniferous strata. At Waterland the carboniferous beds again come to the surface in the Lugton valley, lying to the north-east of the cutting, and boulders of this group again rise to fifty-one per cent. of the whole. Thus the boulders follow the change in the surface strata, lying to the north-east of the cuttings in every instance. Wherever a rock has an extended surface immediately to the north-east an increase in proportion takes place in the boulders of that variety of rock, and, *vice versa*, wherever a diminution of surface takes place in a rock the boulders accordingly are reduced.

In addition to the local boulders, and associated with them, were found those of Old Red Sandstone, granite, quartz, gneiss, mica, and chlorite schists, and clay-slate. Of these the Old Red figured highest. This consists of two varieties, one of a highly red colour, and the other of a dark gray. Both are found *in situ* along the shore, on the Frith of Clyde, near Gourock, but the means of their transport has been different from that of the local boulders. As already stated, the ice-markings upon the rocks of

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the locality have a trend, nearly from north-east to south-west, and as the foregoing shews, all the local boulders have been carried forward for a short distance towards the south-west upon this line. But this cannot have been the natural source of these erratics. A line drawn across Scotland from north-east to south-west, so as to intersect these cuttings, would run nearly through the centre of the carboniferous basin of the central valley, and would not intersect any area of Old Red Sandstone at all. If this be correct as regards the Old Red, it is clearly so with the other erratics. Many writers upon the boulder clay are wholly in error in stating that these erratics are only found in a surface deposit overlying the true till or boulder clay proper, and that their presence is due to icebergs floating over the submerged surface.* If icebergs have been the means of transport, then the transportation can only have taken place previous to the deposition of the boulder clay, and not after it. In these cuttings and in all sections of the boulder clay which I have examined, the erratics are mixed up with it, and associated with the local boulders. In Windyhouse and Highgate cuttings, I found Old Red and schists nearly twenty feet below the surface, and there can be no doubt of the true boulder clay character of the deposit. However, it may be proper to mention that they are not so regularly distributed as the local ones, and lie more in nests or patches; they also appear to occupy what may be called roads in the till, and although found in all positions in it, top, centre, and bottom, the nests occur more frequently near the top than at the bottom, and this may have led some writers upon the subject to believe that they are only found on, or near, the surface. In Bridgehouse burn cutting, no Old Red was found, and only two per cent. of the other erratics, while at Thirdpart, eighteen per cent. of Old Red was found, and ten per cent. of the others. In Roughwood quarry, half-a-mile south-west from Bridgehouse, scarcely an erratic is found, and yet two boulder clays are found here. Again, at Langside quarry, about one mile north-east from Windyhouse cutting, twenty-four per cent. of the boulders are Old Red Sandstone, and eight per cent of the other erratics. The deposit is true boulder clay, the rock beneath it being striated from north-east to south-west, and the erratics found in all parts of the deposit.

It is very easy to invent theories, but the presence of these

* Phenomena of the Glacial Drift of Scotland, page 120 *et seq.*

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erratics in the boulder clay proper may be accounted for by a very simple one, without submergence or icebergs. It is a well-known fact that sheets of land ice carry upon their upper surface large loads of stones, when the tops of mountains which may be adjacent to them are higher than the thickness of the sheets. Another fact equally well known is, that sheets of ice so loaded, in moving over uneven surfaces, become rent into crevasses, down through which the upper load of stones and *debris* find their way to the bottom, and thus become mixed up with the *moraine profonde* or "footboard," existing between the ice and the subjacent rock. If we then admit that the ice movement came from the north (and I cannot conceive of any geologist who has paid any close attention to the deposits of the glacial period denying its northern source), we find mountains in the Highlands that would stand more than a thousand feet above the ice, even granting it a thickness of 2000 feet. Here we have natural quarries to supply all the stones we require. These mountains, having their exposed tops rent by the severe frost, would rain down a continual stream of disintegrated blocks upon the passing glacier. Quarried and loaded in the Highlands, they would no sooner have left their parent locality than a regular sowing of them down through the fissures would commence and continue until the whole were disposed of, which would be many scores of miles from their starting point. This appears to me the most natural way of accounting for their presence in the clay along with the local boulders. Subsequent submergence cannot account for their presence being, as they are, mixed up in the true till. They are too broadly scattered to account for their existence on the surface, previous to the deposits of boulder clay. No local boulders are carried forward a greater distance than ten miles, and few reach this distance, while the erratics are carried 50, 60, and 70 miles from their parent bed, and are found scattered across the central valley from Ardrossan to Leith. No other method, in my opinion, can account for them in these distant localities than the one thus advocated. Some difficulties present themselves in drawing a line of agreement between the direction of striations, as pointing out the line of glacial movement, and the almost north to south motion, as here required. But this is more apparent than real. It is now well ascertained that ice in motion follows the same law as water or any other liquid. Acknowledging the boulder clay to be the production of

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land ice, that is, an extension of the circum-polar ice-cap, and not local glaciers originating from some mountainous centre, I think it is demonstrated by the evidence collected, that while the main motion was from the north, or nearly so, there would be a tendency to follow the valleys when they did not diverge more than 30° from the line of main motion.

Writers upon the boulder clay have been in the habit of assuming that the whole of the boulders in the clay have been carried forward in the same manner as I here claim for the erratics, but this will not bear the slightest investigation. In the locality around the north of these cuttings none of the local boulders could have fallen upon ice 100 feet thick, with the exception of the Cuffhill and Gleniffer porphyrite. The highest point of Gleniffer above the sea level is 848 feet, that of Cuffhill 675 feet, and that of the highest limestone is at Hillhead, 400 feet. The height of the railway cuttings above the sea level is 293 feet at Windyhouse to 458 feet at Highgate, the summit level. Thus the difference between the latter and Gleniffer is 390 feet, of Windyhouse and Cuffhill 360 feet, of Hillhead 107 feet. And then there are boulders—the ironstones, for example—that come from beds nearly level with the deposit in which they are found. These figures tend to negative the theory of these boulders being produced from falling upon the surface of land ice. But independently of this, the position of the boulders in the clay is proof against the hypothesis, and clearly in favour of these local boulders being taken up and carried in the "footboard" of the ice. The majority have not been carried forward more than three miles. A few reach five miles, and a stray one may be found even at the distance of ten miles, but the occurrence of the latter is very rare. The examination of a few miles of a locality along the line of ice-motion will establish the fact. At Langside quarry, eight per cent. of the boulders are from Cuffhill, and at Windyhouse, one mile farther to the south-west, this variety has fallen to one per cent. At Windyhouse thirty-one per cent. of the boulders are from the Broadstone limestones, while at Muirhouse only three per cent. of limestones were traceable to Broadstone. The distance is about $3\frac{1}{2}$ miles from the latter place to Muirhouse, in a south-west direction. But this is a fact so well-known that it would only be repeating to enlarge upon it. Even Hugh Miller, in the palmy days of the iceberg theory, mentions that, when travelling, he always knew

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when a change of rock took place by the boulder clay assuming the colour of the underlying rock. This is just what the enumeration of these boulders substantiates, viz., that the change in the boulders follow closely the change of surface strata.

Another inference drawn from the foregoing evidence leads to the belief that the boulder clay and local boulders are lying in irregular squares, each square mixed up slightly with its neighbour, but perfectly distinct from the square beyond. This regularity of sequence could not have taken place if the boulders had been dropped through fissures from the upper surface of the ice. No such regularity is found; as regards the erratics, they are found more or less in every square. Not so the local boulders; they change as regularly as the surface strata. This may be accepted as another proof that the boulder clay proper is an accumulation from land ice, and also that the boulders and finer clay mixed up with them have been taken up and moved forward beneath the ice as a "footboard," the erratics always excepted.

In addition to the boulders, two fragments of oak, *Quercus pedunculata*, were found in the cuttings; the largest one, three feet seven inches long, and seven inches in diameter, was found in Manneraheads cutting; the lesser one, one foot six inches long, and three inches in diameter, was found in Windyhouse cutting. They were both found on the same horizon, in an upright position, in a bed of clay that differed slightly in character from the underlying boulder clay. This clay, which was almost free of large boulders, contained no limestone boulders, and filled up small basins or hollows in the true boulder clay. The Windyhouse basin was about sixty yards in length, and $4\frac{1}{2}$ feet deep. Two of these basins occurred in the Manneraheads cutting, but more irregularly in depth, being from two to five feet. The smaller fragment was found in the bottom of the basin, about $4\frac{1}{2}$ feet below the surface, and the larger about three feet from its upper end, and, consequently, nearly 7 feet from its lower one. A very thin layer of peat or sand made the line of division very distinct betwixt the clays. Roots of the common hazel, as well as stems, were found, both in an upright and horizontal position, in both cuttings, mixed up in the bottom of the upper small basins. In the Windyhouse cutting, clear evidence was found of trees of considerable size having grown upon the surface of the underlying boulder clay, previous to the deposition of the upper basin. Roots

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were found from three to four inches in diameter, and one of the latter I traced for six feet without finding its termination. There is no doubt but that they were in the position in which they had grown; the smaller roots branching off from the larger, in a manner that could not be mistaken. They were too much fermented and decayed to distinguish their species; although I am of opinion that they belong to the oak, still this cannot be affirmed as positive.

Conclusion.—In bringing these observations to a close, a few questions force themselves upon the mind, arising from the facts collected. One question has struck me very forcibly when collecting evidence in the field. Are the theories which give such large excavating power to the glacial period compatible with the evidence now furnished by the excavations? These excavations now found in the form of boulder clay are, as I have attempted to show, of a thorough local and sporadic character. If hundreds and thousands of feet of strata have been removed by the ice, as Professor Ramsay affirms, would the excavated remains be thus so strictly local in character as they are now found? Another part of the evidence is, in my opinion, against these theories of large excavations performed by ice during the glacial period. When we see a railway cutting we are sure to find an equivalent embankment, and the same ought to hold good with valley-excavation. But when we turn to the boulder clay embankments we do not find such stores of it as would warrant the assuming of thousands or even hundreds of feet having been removed by ice during the glacial period. Mr. Croll, in a paper on buried river channels below the boulder clay, gives the average in 250 bores, taken from all the mineral fields in Scotland, as 86 feet for the boulder clay. The average in 22 pits and bores in the Carmel valley, near Kilmarnock, is 55 feet, and this is about the average depth in the Garnock valley. The two last take in all the surface deposits as well as the boulder clay, and I strongly suspect that Mr. Croll's average does the same. If the average could be found over the whole country, the thinness of the deposit would be something astonishing. But then denudation is brought in to account for this present sparseness of it; yet, very little denudation can have taken place in the lower ends and mouths of the valleys since the glacial times. Up to about 100 years ago all the level lying lands in the valleys were accumulating

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deposits instead of being areas of denudation. Previous to the modern system of agriculture, the Scottish rivers were allowed to choke up, and when in flood to spread all over the level lands, dropping the sediment brought from the rocks higher up, and thus forming deposits of sand, mud, and gravel, or all three combined. These deposits are now found overlying the boulder clay in places many feet thick, and have thus preserved it, the deposits having most likely been commenced at or near the close of the glacial period. Little or none of the boulder clay exists upon the hills or higher lands if we except hollows and ravines, and it is very questionable if ever it existed there in any considerable quantity. If the boulder clay is accepted as a deposit which has accumulated and been deposited under the ice sheets, and no other method can so plausibly account for it as it now exists, little or none of the grindings would be left upon high exposed and rounded heights. Even on knolls in the lower lying areas the deposit appears never to have been great. This is best understood where limestone is the surface strata. At Trearne a quarry has been opened in an anticlinal boss of this rock. On the two flanks lie a covering of boulder clay, and beneath the one removed, the limestone surface was polished and striated, showing one of the finest pieces of ice-work any where met with. The boulder clay covering was about 15 feet, running off near the apex of the anticlinal. Below the boulder clay, up to its very edge, the polish and striæ were well marked, but over the top of the limestone knoll a very thin covering of earth, barely covering the rock, took the place of the clay, and here the limestone was eaten into in places as deep as 10 feet, with a width of three to four feet, terminating in a point in the bottom of the eroded gutter. This is only one of many places wherein the same thing takes place in the locality. Now, if this boss of limestone had been covered equally over, the apex of the boss might have been denuded away first; but after it had been so denuded (granting its presence) the flanks would also have been cleared during the immense period that must have elapsed while the limestone was being eroded into the large pits and crevices that now exist in it. That is, if the boulder clay has been denuded from off the apex of the limestone boss, the denudation must have all but ceased upon the clay covering the flanks, as the time required to erode and fit the limestone into its present state will have been sufficient to have cleared the whole clay from

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off the anticlinal, which is not the case. This is only one of many instances that could be cited in proof of the boulder clay having been originally very unevenly laid down; but as this is going beyond the scope of this paper, and as the subject requires, and is well worth a paper by itself, I defer at present from entering any further into it.

I have already described the clay in which the two fragments of oak were embedded, but whether they are fragmentary remains of another and upper bed of boulder clay, is a question which I am not prepared to answer. There can be no question of two boulder clays existing in this locality, but the evidence, as far as I have examined, tends rather in favour of the upper clay being a water production than of land ice, or what is more likely to turn out, the result of drift ice.

The following is a list of places where glaciated rock surfaces were found with the direction of striæ taken per compass:—

DIRECTION OF STRIÆ IN THE LOCALITY OF THE BEITH RAILWAY.

Localities.	Direction.
Lochwinnoch, Renfrewshire.	
Nethertrees water dam, below boulder clay on porphyrite,	N.E. to S.W.
Beith, Ayrshire.	
Hillhead of Broadstone, on limestone,	N.E. by E. to S.W. by W.
Trearne,	N.E. by E. to S.W. by W.
Manse, New Railway Station, on porphyrite tuff,	N.E. by E. to S.W. by W.
Roughwood, on limestone,	N.E. by E. to S.W. by W.
Thirdpart, on limestone,	N.E. by E. to S.W. by W.
Tandlehill, on porphyrite,	N.E. by E. to S.W. by W.
Bar, on sandstone,	N.E. to S.W.
Cuffhill, northern side, on porphyrite,	N.E. by E. to S.W. by W.
Langside, on limestone,	N.E. to S.W.
Neilston, Renfrewshire.	
Lochlibo, on sandstone, near west end,	N.E. by N. 40° to S.W. by S.
Dunlop, Ayrshire.	
Waterland, on limestone,	N.E. 50° to S.W.

The above direction of striations taken from twelve places in the district shows that the ice movement has been nearly from the N.E. to S.W., deflected a few degrees by the contour of the surface. The boulders correspond with this, or very nearly so, all along the line.

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V.—*On a Specimen of* ACANTHODES WARDII, Egerton, *from the Lanarkshire Coal Field.* By JAMES THOMSON, F.G.S.

PLATE IV.

(Read November 3, 1870.)

FOR a number of years I have frequently found small, curved spines, grooved parallel to the plane of the anterior face, embedded in the carbonaceous shales that overlie the Palace Craig black-band ironstone in the neighbourhood of Airdrie, and also in the roof of the splint coal at Newmains, Wishaw, and Newton, near Cambuslang. As they had not been found associated with other parts of the fish, I felt unable to establish their generic or specific characters. Associated with these were found small scales, confusedly scattered over the slabs of shale. In form they are rhomboidal, smooth, and much raised in the centre. Associated with these were portions of what appeared to be shagreen.

The doubts surrounding these interesting forms were happily dispelled by the discovery, in the spring of this year, of a portion of a tolerably-well-preserved specimen of *Acanthodes*, with the ventral, anal, and a part of the dorsal spine, in position, contained in a slab of the Palace Craig ironstone. The specimen measures, from near the extremity of the caudal fin to an inch beyond the ventral spine, fully fifteen inches.

Through the kindness of Mr. John Ward, Longton, Staffordshire, who forwarded me a specimen of *Acanthodes Wardii*, I was enabled to compare my specimen with it; and finding it agreed in every detail with that species, except in the size,* I had no difficulty in recognising in the Lanarkshire specimen both the generic and specific characters of that species.

The structural characters of this fish have been so ably described by Sir Philip Egerton that it is unnecessary to do more than give a few of the details exhibited in our specimen. The length, as before stated, is fully fifteen inches. The slab is broken about an inch

* In a note lately received, Mr. Ward informs me that he has lately discovered a portion of a large *Acanthodes*, which he believes to be *A. Wardii*.

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beyond the ventral ray, consequently the anterior part of the body and the head are wanting. It is divided into the following proportions:—From the point where the spine of the ventral fin is inserted into the body to the base of the anal spine, six inches; from the base of the anal spine to where the vertebral axis bends upwards to the upper lobe of the tail, six inches; and from the point where this axis bends upwards to the broken portion of the tail, two inches.

The dorsal spine is situated above, and an inch behind the anal fin, and is two and a half inches long. Its outline is acutely triangular, and it is grooved on each side parallel to the anterior face, and obscurely grooved at the base where it is seen to enter the body of the fish. It supports a large and somewhat triangular fin, which passes to near the apex of the spine.

The anal spine is somewhat stouter than the dorsal, and is $2\frac{3}{4}$ inches long. It supports an unequally lobed triangular fin, one side of which extends along the body of the fish towards the tail. At the base, and behind the spine, are a number of minute rays, about a line and a half long, which are seen to connect the fin to the body.

The ventral spine, as above stated, is situated six inches before the anal. It is, however, only a fragment, and is broken about half an inch from its base. Faint traces only of the fin remain, obscurely seen, passing to half the distance in front of the anal spine; but it is not sufficiently preserved to enable me to determine either its form or extent. In a specimen which Mr. D. J. Brown, of Edinburgh, kindly sent me from the Wallieford coal field, Midlothian, the fin is seen to pass to near the base of the anal spine. All the spines are slightly hollowed along the posterior face where the fins have been attached. The tail is heterocercal. I am not aware how far the upper lobe extends, it being broken; but if I may judge from the proportions of the specimen referred to above, it would extend, at least, fully two inches longer than the point indicated in the plate.

The inferior lobe is well preserved. At its base are seen well-defined fin rays, which diminish in size as they ascend along the upper margin of the lower lobe.

The dermal investure consists of rhomboidal ganoin scales, raised in the centre into somewhat circular eminences. (See Fig. 1 *a*.)

Geological position.—Upper coal measures in shale above the

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Palace Craig and Airdrie blackband ironstone, and shale above the splint coal, at Newmains, Wishaw, and Newton, Cambuslang.

EXPLANATION OF PLATE.

PLATE IV.

Fig. 1.—*Acanthodes Wardii*, Egerton, reduced in length two inches.
,, 1 *a*, Part of rhomboidal scales magnified.
,, 2.—Dorsal spine.
,, 3.—Anal spine.
,, 4.—Ventral spine.

VI.—*On* CTENACANTHUS HYBODOIDES, *Egerton.*

By JAMES THOMSON, F.G.S.

PLATES II., III.

(Read December 2, 1869.)

MANY of the spines found in carboniferous strata have been enshrouded in so much obscurity, that any observation which will contribute to their proper classification is of importance to the palæontologist.

The form and structure of the spines of *Ctenacanthus* have been described by Professor Agassiz; but I am not aware that the spines of the species which forms the subject of this communication have been described as constantly or intimately associated with other head-parts, such as might suggest the particular animal to which they belonged. Teeth and spines have received distinct generic names. Our information not sufficing to determine the spines and teeth which belonged to the same animal, I propose to attempt such a determination in the case of *Ctenacanthus hybodoides.*

In the spring of 1869 I was fortunate in obtaining a slab of the Palace Craig ironstone from Carnbroe, near Airdrie, which contained, 1st, a mass of shagreen; 2nd, two spines of *Ctenacanthus hybodoides** (Plate II., fig. 1, 1 *a*, and 1 *b*); 3rd, a number of the teeth *Cladodus mirabilis* (Plate III., fig. 1), all evidently in their proper relative positions, the slightly curved lines in which they are disposed suggesting the contour of the mouth; and, lying at a higher level than these, there is exposed, 4th, a fragment of a small spine, the cross section of which gives in outline an oblong

* Described as *C. magnus* in Brit. Assoc. Report, 1869.

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sphere, with the posterior side shorter than the other. The anterior face is round and smooth, while the posterior is flat, and along the margin of which there are two rows of pointed tubercles curving inwards and downwards. Being thus found on the upper surface of the head, it is natural to infer that it was situated on the occipital region of the fish. Subsequently, I removed a portion of the ironstone that enveloped the posterior face of the spines, which revealed a double row of tubercles passing from the apex to the base along the lateral margins of the posterior face, a character which distinguishes this species. (Plate III., fig. 1 *a*.)

On removing the ironstone from the under side of the slab immediately over the mouth, I exposed the skin, and found embedded in its substance numerous minute bodies, consisting of two, three, and four curved diverging points rising from an expanded base, from which a sharp keel on the convex side passed to the apex of each of the points. On other parts of the slab, I found other pieces of the skin, larger than those found on the crown of the head, but possessing similar tooth-like bodies, divided into two, three, four, and in a few instances into six divergent points, and keeled along the convex or dorsal side. (Plate II., fig. 4, 4 *a*, *b*, *c*, *d*; 5, 5 *a*, *b*, *c*, *d*.)

Subsequently, I found other slabs of the ironstone at the same place, one of which contained the teeth of *Cladodus mirabilis*, and a fragment of a spine similar in structural character to the one formerly mentioned, all embedded in a patch of shagreen. I was thus led to suppose that they might be referred to the same genus. In another slab, I found embedded en a patch of shagreen the so-called teeth of *Diplodus gibbosus*, very numerous, and crowded together without order; and associated with these there is another form of tooth-like tubercles, smooth, enamelled, circular in section, and relatively larger, while the recurved apex is more pointed than the tubercles before described. They are occasionally found in patches of greater numbers, in some instances in clusters of eight and nine, and are all attached to broad, flat bases. Finding such an amount of co-related evidence, I was led to prepare microscopic sections of patches of the shagreen, which I detached from the mass. (Plate II., 3, 3 *a*.)

After doing so I was led to consult the results of other investigators, and found that Professor Owen, in a paper published by the Odontological Society, had described a number of similar

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forms discovered by Mr. Craggs in the Newcastle coal field. He describes them as teeth, and to some he has given the names of *Ditodus divergens*, *Mitrodus quadricornus*, *Ochlodus crassus*, *Gastrodus prapositus*. (Transactions of the Odontological Society of Great Britain.)

Finding some of the forms described by the learned Professor agreeing in detail with the sections I had made, I felt much puzzled at finding all the different forms distributed over and attached to the same shagreen; and in order that I might arrive at a somewhat satisfactory conclusion, I examined a number of the recent Rays, and found on the male fish of *Raia clavata* very satisfactory results. On closely examining the skin of this species, I found tooth-like dermal spines as varied in form and number of denticulations as in the fossils under consideration. Around the orbits, all over the head and along the mesial ridge to the posterior extremity, they are diffused in considerable numbers; but more especially towards the posterior extremity are those large tooth-like dermal spines, broad at the base, and attached to the skin of the fish, while on the body of the fish they are much more sparingly developed. But all over the body there are profusely developed small dermal processes, in general tripartite, the central denticle being much longer than the two laterals; others are divided into four—the latter form much less frequent than the former; while on the dorso-lateral extremity and around the orbits there are minute dermal processes, with only one conical sharp-pointed denticle. On other parts of the body some are delicately pointed, while others are bent nearly at right angles to the plane of the base, and they all are recurved towards the posterior extremity.

On the head of the female of *Raia clavata* I found the large dermal processes much more obtuse than those of the male, and the small dermal tooth-like processes in general terminating in one denticle; but, instead of having an even contour as in the male, they are keeled.

Founding my observations on the analogy of existing Rays and Sharks, my conclusions are—

1. That the two spines of *Ctenacanthus* belonged to the same animal—both probably spines of dorsal fins, the smaller being the anterior.

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2. That the animal was provided with the teeth known as *Cladodus* of Agassiz.

3. That the body of the animal was covered with fine shagreen.

4. That among this fine investiture were scattered the so-called teeth of *Ditodus*, *Mitrodus*, *Ochlodus*, and *Gastrodus*, which bear the same relation to the shagreen as the placoid armature does to the fine denticulate tubercles of existing Rays.

5. That among the living forms, sexual differences are to be noted in the dermal developments—differences which find their probable counterpart in the fossils. The dermal characters in the fossils are those of Rays—the teeth are more like those of Sharks, to which section also belong the two spinigerous dorsal fins.

Whether the views here stated be accepted or rejected, I hope the identification here attempted may serve as a basis for further observations.

EXPLANATION OF PLATES.

Plate II.

Fig. 1.—Slab of the Palace Craig black-band ironstone, reduced to one-fourth, containing two dorsal spines, figs. 1 *a* and 1 *b*, and shagreen, with dermal tooth-like bodies.

Fig. 2.—Spine of *Ctenacanthus hybodoides*, Egerton, restored.

Fig. 3.—Microscopic section of shagreen, magnified 12 diameters, 3 *a*, vertical section of shagreen, magnified 7 diameters.

Fig. 4.—Dermal tooth-like bodies, natural size; 4 *a*, 4 *b*, 4 *c*, dermal tooth-like bodies, in groups of two, three, and four, respectively, magnified 9 diameters; 4 *d*, side view of same, showing its curved outline and groove on the anterior face, magnified 9 diameters.

Fig. 5.—Natural size; 5 *a*, 5 *b*, 5 *c*, 5 *d*, tooth-like bodies, in longitudinal section, magnified 9 diameters.

Plate III.

Fig. 1.—Ironstone, containing part of the gape of *Ctenacanthus hybodoides*, with teeth *in situ*; 1 *a*, ironstone, with impression of headspine removed from the mass.

Fig. 2.—Headspine, natural size, restored; 2*a*, side view of the same; 2*b*, transverse section, natural size; 2 *c*, the same magnified 11 diameters.

Fig. 3.—Tooth removed from its position in the mouth, magnified two times; 3*a*, microscopic vertical section of the same.

Fig. 4.—Dermal structure, natural size; 4*a*, dermal structure, magnified 9 diameters.

Note.—I beg to thank Professor Young for his assistence in the identification of the different parts of *Ctenacanthus*.

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VII.—*On the Aspects of* Clydesdale *during the* Glacial Period.

By Dugald Bell.

(Read April 9, 1870.—Abstract.)

The author said it was remarkable that some of the most difficult problems of geology should spring up and present themselves within a few feet of the surface on which we stand. After journeying with comparative sureness of footing across the vast spaces represented by the earlier formations, geologists had been arrested for more than a quarter of a century in front of the covering of loose stones, clays, and gravels spread over the whole. He need not recount all the hypotheses by which they had tried to explain what had been variously styled the *Northern Drift*, *Diluvium*, *Till*, or *Boulder Clay*. It came to be seen that these surface deposits presented a very complex problem, and that no single or transient cause, such as powerful currents, "waves of translation," or great floods of water, could at all meet the case. By slow degrees, and after a world of labour, they had at length succeeded to some extent in unravelling the mystery of the boulder clays and associated deposits, and so deciphering a very wonderful chapter of the earth's history, of which these are the record. He then gave an outline of the succession of events which had been made out from the dawn of the glacial epoch down to a comparatively recent geological time,—beginning with the period of land-ice and ending with the "last elevation" of the land.

This succession, as now generally concurred in by those who had investigated the subject, was as under :—

1. A period when the land stood higher above the sea-level than at present, and when land-ice, like that under which Greenland now lies buried, prevailed. *Lower till* or *boulder clay*.

2. A period of depression, during which all but the higher mountains were submerged; the climate still continuing severe. "*Middle-drift*," *laminated clays*, *shell-beds of northern types*.

3. Land re-elevated to somewhat higher than its present level; partial recurrence of land-ice—second and more local glaciation. *Local moraines* and *upper boulder clay*.

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4. Second depression, but much less than the former, accompanied also by greater mildness of temperature. *Sea-margins* and *estuarine deposits.*

5. The "last elevation" of the land.

He contrasted this scheme with the more complex one proposed by Dr. Robert Chambers in 1861, in his "Ice and Water: or a Review of the Superficial Formation."

As to the period of land-ice, he thought the first point which they had to fix in their minds, and try to get some adequate notion of, was the great thickness and mass which the ice attained. He did not know where they could get a better or more impressive idea of this than by ascending Benlomond. He described the marks of the ice, the grooved and polished surfaces, that may be traced from the shore at Rowardennan to a great height on Benlomond, observing that the ice evidently did not come *down* the mountain, but moved *along* or *across* it. He also referred to similar markings on the neighbouring hills, and the conclusion these all led to was, that the entire hollow in which Lochlomond now lies was at one time filled from side to side with a mass of ice, which only the higher mountains overtopped, and from which Benlomond itself only rose as a little rocky islet. Having shown that this was quite in harmony with what had been observed in other parts of the country, among the mountains of Perthshire, Aberdeenshire, and Argyllshire, he said he had no doubt the great depth of Lochlomond, in its upper part, where it is not less than 100 fathoms, was due mainly to the action of the ice, which was there compressed and imprisoned, forcing its way between the hills. In the lower part it got spread out more, so that, although it had softer rocks to deal with, it produced a comparatively less effect. He then alluded to similar proofs of glacial action in the neighbouring parts of the Frith of Clyde. At Garelochhead, and all along the shores of that Loch, of Lochlong, Lochgoil, and the Holy Loch, the marks of glaciation are striking and abundant. At Strone Point, from beneath the water to some height on the hillside, there is a great accumulation of travelled blocks; two streams of ice, that from Lochlong and that from Loch Eck, having evidently joined here, forming a medial moraine, part of which was here deposited, and has since been broken up and dispersed, to some extent, by the sea. Crossing to Gourock, on the opposite side, where there are only sandstone and trap rocks *in situ*, we

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find, along the shore and to some height on the hillsides, a continuation of the same train of schistose boulders, many of them of considerable size and very distinctly striated. On the hills behind Gourock and Greenock, striated surfaces are visible, pointing across the Frith to the north-west. On the road from Port-Glasgow to Kilmalcolm and Bridge-of Weir similar instances may be observed—hard trappean knolls ground down and polished, and bearing testimony, by the distinct traces they still retain, of the powerful agency to which they were subjected. The striations here maintain the same general direction from the north-west. Dumbarton Castle rock also presents a remarkable instance, which was described by Captain Brickenden a good many years ago;* the sides of the fissure pointing north towards Benlomond—the western side especially, though it leans over at a high angle—being finely polished and striated; recalling an observation by Charpentier, one of the early students of glaciers, that "they follow all the sinuosities, and press and mould themselves into all the hollows and excavations they can reach, *polishing even overhanging surfaces*, which a current of water, hurrying stones along with it, could not effect." On the Kilpatrick (trap) hills, similar traces are to be found, and portions of slate and quartz rock strew the surface at considerable heights. All over the more open grounds, from the Gleniffer and Cathkin Braes on the one side to the Campsie hills on the other, wherever a surface of rock is exposed, such markings present themselves. The whole valley of the Forth and Clyde is covered with *debris* from the schistose mountains to the north west; and this, together with the persistence and uniformity of direction of the markings, alike in the valley and along the neighbouring hills, sufficiently proves the great volume which the ice must have attained. He then proceeded to consider the formation of the boulder clay, holding that the lower Till or clay was the product of this great sheet of land-ice, and that the upper boulder clay was more probably due to sea-ice during the period which followed, when the land was submerged to a depth of several hundred feet beneath its present level. In many cases, also, he believed an upper boulder clay was due to the second and more local glaciation which ensued on the subsequent re-elevation of the land. He referred to the beds of sand found interspersed throughout the boulder clay, and thought that,

* Quar. Jour. Geol. Socy. Vol. XI. (1855.)

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whether the theory of land or sea-ice were adopted, these might be explained without supposing, as some did, that there had been so many distinct "breaks" in the glacial period. He pointed out the narrowness of the basis on which such conclusions had been arrived at, only a very few of the borings which had been adduced showing more than one or two beds of sand;* and maintained that the one "break" of which we seemed to have evidence was sufficient, if we considered and gave due weight to the gradual advance and retreat of the ice in each case, and the accumulation of waters that must have been caused thereby, to account for all the beds of sand that had been described. He thought there was every probability in the suggestion that some of these beds of fine sand, found in connection with the boulder clay, and which are singularly free from grit or pebbles, and devoid, so far as yet known, of any trace of life, might be due to glacial or interglacial lakes, formed on the more open grounds during the gradual advance, or again, during the equally gradual retreat of the ice. There was no reason to suppose that the present channel of the Clyde near Bowling continued free and open during the whole of the glacial period, or indeed that it existed at all, as a channel, during the greater part of that period; and if at any time it were blocked up, either by ice or its accompanying *debris* (of which, as we have seen, there are abundant traces on both sides of it), then the waters of Clydesdale, forming an extensive lake, or series of lakes, to the eastward, might find egress by some other channel, possibly in a different direction altogether. At present, if from any cause the channel by Bowling were closed up, the waters, after rising about 100 feet, would find egress by the south-western valley of Lochwinnoch and Dalry. And there was certainly every indication of there having been a great outflow of water in that direction at a period geologically not very remote. Coming, next, to the "shell-beds" which had been found at various heights in the Clyde valley—from Airdrie at 510 feet, down to Paisley, and from that to the present sea-margin—he was of opinion that the theory of "unequal elevations," which had been proposed† to account for these beds being found at so many different levels, was

* For example, out of 59 bores referred to by Mr. Bennie (Transactions of this Society, Vol. III., p. 136), 45 had only *one* bed of sand, ten had *two*, and only four had *more than* two such beds.

† *E. g.*, by Mr. Crosskey: Trans. of this Society, Feb., 1865.

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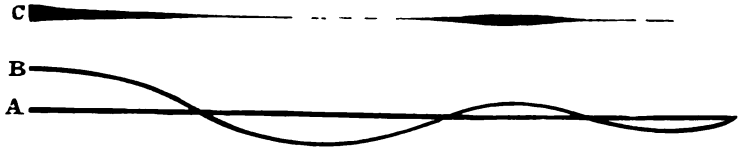
quite untenable. He believed the true explanation was to be sought, not by supposing the beds to have been strictly *contemporaneous*, or formed at the same level and afterwards "unequally elevated," but by considering them to have been *successive*, formed at different levels during the gradual sinking or rising of the land, as the depth of the sea, its freedom from ice, and other conditions, became favourable to the various forms of marine life whose remains are found in the beds referred to. Some other points connected with the subject he might allude to on a future occasion. Meantime, the general succession of events to which he had referred might be presented in a diagram, as under :—



A. Present sea level.

B. Elevations and depressions of the land.

C. Intensity of cold.

There thus appears to have been a correspondence, as one might expect there would be, between the elevation of the land and the prevailing temperature—a correspondence, however, not absolute (period 2 being colder than period 4), but modified by other causes.

The following tables of the surface deposits in the valley of the Clyde might be useful for reference :—

1. At Windmillcroft.

River drift.
Clay bed (arctic shells).
Fine white sand.
Boulder clay.

2. At Dalmuir.

Sand and gravel.
Clay and sand (arctic shells).
Boulder clay.

3. At Paisley.

River drift.
Littoral shell bed.
Brick clay (no shells).
Shell clay (arctic species).
Finely laminated clay (no shells).
Boulder clay.

4. At Kilchattan Bay.

Vegetable soil.
Stratified gravel and shingle.
Red clay (no shells).
Shell clay (arctic species).
Finely laminated clay (no shells).
Boulder clay.

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The stony materials of the boulder clay around Glasgow occur in the following proportions :—

Sandstone and shale (from the subjacent coal fields),	about 60	per cent.
Trap (from the Kilpatrick hills),	,, 30	,,
Clayslate, &c. (Dumbarton and Argyleshire hills),	,, 10	,,
Granite (from a greater distance),	,, 1	,,

NOTES TO THE FOREGOING PAPER.

1. While the general direction of the striæ in the neighbourhood of Glasgow is from the west—varying a little, in some localities, to the north or south of west—with which also the kinds of boulders embedded in the clay correspond—in the Beith district the direction is quite different, being, as Mr. Craig has observed, from the N.E., from which direction also, as shown in his valuable paper, the boulders in that district have been derived. Near Paisley, however, and between Paisley and Barrhead, the striæ maintain the normal direction of those in the Clyde valley from the N.W. There thus appears to have been a *curve* or *shedding* of the ice along the hills in the neighbourhood of Johnstone, an idea which occurred to the writer some years ago, and which observations since made in that quarter confirm.

The ice, in short, seems to have spread out in a fan-like shape from the mountainous districts to the west, passing at first with great uniformity of direction over the lesser elevations, but afterwards, as it shrank in bulk, accommodating itself to the inequalities and taking its direction from the general inclination of the ground. There, is therefore, no necessity for supposing (as some had been inclined to do) that we should look from Beith in a north-easterly direction, across the coal field of the central valley to the distant highlands of Perthshire, for the origin of the fragments of schist and Old Red Sandstone found in the boulder clay of the Beith district. Borne across the flanks of the Kilmalcolm hills, and deflected to the south in their progress, they doubtless came from the same quarter which has supplied the contents of the boulder clays around Glasgow, viz., the hills of Dumbartonshire and Argyleshire. It can scarcely, indeed, be imagined, that while the boulders scattered around Glasgow were derived from points lying to the north-west and south-west of the city, a similar set should have found its way to Beith *across* them, from the opposite side of the island.

2. There is no more frequent topic of discussion among geologists than the part which land and sea-ice respectively have played in the formation of the boulder clay. Some attempt to account for the whole of that formation by land-ice, while others are equally bent on admitting nothing but sea-ice, and represent it as adequate even to account for boulders being found "several hundred feet above the parent rock," as "icebergs have been seen to turn over while drifting in the sea, and in doing so might possibly fling rocks and rubbish to a higher level"(!) * The quarter whence this suggestion comes is entitled to great respect; but surely it is an instance of how far an able man wedded to a theory will go. One may hold that there is a decided preponderance of evidence in favour of the conclusion, that at least the lower boulder clay is the production of land-ice. But one is not, therefore, obliged to exclude the agency of floating

* Mr. D. Milne Home on the Estuary of the Forth.

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ice altogether. To those who are fanatical on either side—either for glaciers or for icebergs—it may be well to recall an observation by Hugh Miller, that "the iceberg and glacial theories, so far from being antagonistic, ought rather to be regarded as equally indispensable parts of one and the same theory. . . The fact that more than four thousand square miles of the interior of Iceland are covered by glaciers is in no degree invalidated by the kindred fact that its shores are visited every spring by hundreds of thousands of icebergs." * To which we may add an observation by Sir Charles Lyell, that "there will often be no small difficulty in distinguishing between the effects of the submarine and supra-marine agency of ice." †

1871. D. B.

* Sketch Book of Geology, p. 59.

† Antiq. of Man. Chap. xiii.

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PROCEEDINGS FOR THE YEAR 1869-70.

NOVEMBER 11, 1869.

Professor JOHN YOUNG, *President*, in the Chair.

Messrs. J. Campbell Douglas, 48 Abbotsford Place; Douglas Spiers, M.D., 170 Sauchiehall Street; David Pratt, 80 Great Clyde Street; John Orr, 392 Gallowgate; and John Steven, 28 St. James' Street, Kingston, were elected resident members.

The PRESIDENT exhibited, on behalf of Mr. Robert Craig, Langside, Beith, a fish spine, new, so far as could be ascertained. The peculiar ornamentation, to which the scale-pattern of *Gyrolepis Rankinii* had the nearest resemblance, offered a very easily recognisable character; and as the suggestion was less of ridge than of grooves cut out, leaving prominent intermediate portions, the name *Glyptacanthus confluens* was proposed provisionally. Ere long its systematic position would, it was hoped, be determined by the help of fresh specimens.

Mr. JOHN BURNS exhibited vertebræ, finger bones, etc., of a young or small species of seal found in the alluvial deposits of the valley of the Forth, near Falkirk, in the recent sinking of a pit, and at a depth of seventy feet from the surface; and made some observations upon the character of the beds.

Mr. Burns also exhibited a decayed piece of oak from the new Stobcross Docks, which was surrounded by a thick incrustation of highly ferruginous sand, and stated that these incrustations were common in the sand-beds of that locality, and are probably caused by plants attracting a certain amount of iron during their decay, which incrusts and hardens the surrounding sand.

Mr. John Young exhibited and made some observations upon a number of bones found near Crofthead, in the new railway cutting of the Crofthead and Kilmarnock Extension Line. These bones had been forwarded for examination to the Hunterian Museum by Mr. Strain, the engineer, and Mr. M'Naughton, contractor for the works, at the suggestion of Mr. Robert Craig, Langside, Beith, who afterwards read a paper bearing partly upon the deposits in which the specimens were found. Mr. Young stated that Dr. Young and himself had examined the bones, and found that ten of them belonged to a horse, about one-third smaller than the average size, but probably of the common species, *Equus caballus*. Other two were portions of the horns of the extinct gigantic Irish deer, *Megaceros Hibernicus*. These remains were found in the upper portion of a thick bed of laminated clay, which at this part of the valley is mixed up with such an amount of vegetable matter that it presents quite a peaty character. They lay on the same horizon, and near to the spot where the skull of the extinct wild ox, *Bos primigenius*, was found some time ago. The depth at which they occurred below the old surface of the valley is nearly twenty feet, but recent cuttings seem to show that part of the overlying bed is the result of slips of earth and boulder clay from the hillside over deposits formed in the bottom of an old lake.

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This appears to be the second instance only in which the *Megaceros Hibernicus* has been found in Scotland. A fine head, with horns attached, each horn measuring five feet in length by two feet seven inches in breadth, was found many years ago, associated with a skull of *Bos primigenius*, a horn of *Cervus elephas*, and other remains not identified, in the southern part of the parish of Maybole, in Ayrshire, while digging out the shell marl in an old silted-up lake in that district.

The Crofthead specimens of *Megaceros Hibernicus* consist of the lower portion of a shed horn from the left side of the head, measuring nine inches in circumference round the beam, between the burr and brow tyne, and a fragment of what seems to be a broken tyne of another horn of the same species of deer. Mr. Young also stated that this seems to be the first recorded instance in which the remains of the horse have been found associated with the large extinct mammals that roamed in the valleys of Scotland in post-pliocene times. Sir Charles Lyell records the occurrence of the horse in recent shell-marls filling up the beds of certain small lakes in Forfarshire, but there it was associated with the remains of mammalia of existing species. There can be little doubt, however, that the bones of the horse found in the Crofthead deposit are of equal antiquity with the now extinct *Bos* and *Megaceros;* but after a recent examination of the beds, he (Mr. Young) would not be inclined to place these animals in any earlier deposits than the post-pliocene beds of this country, in which similar remains have been found.

Mr. Robert Craig, Langside, Beith, read a paper "On the Section on the Crofthead and Kilmarnock Railway, in Cowden Glen, Neilston, Renfrewshire, with remarks on the Upper Boulder Clay," (p. 17.)

The discussion on the Crofthead section was postponed till next meeting, and it was arranged that an excursion to the locality should take place on 13th November.

December 2, 1869.

Mr. John Young, *Vice-President*, in the Chair.

Dr. John Dougall, Catrine, and Mr. James Docherty, artist, 82 West Nile Street, were elected, the former as a corresponding, the latter as a resident member of the society.

Mr. Archibald Robertson exhibited, under the microscope, a number of sections of Scottish granites and agates.

Mr. J. Wallace Young read a paper "On the application of the Microscope to the examination of Rock Structure and Composition." The author stated that although a mineral or rock might appear to the naked eye quite amorphous, yet when sections were prepared and examined by the aid of the microscope they presented a well-defined crystalline structure. By this method geologists would be enabled to distinguish rocks of igneous from those of sedimentary origin, or, as it sometimes happened, rocks originally sedimentary, which through metamorphism by water or atmospheric changes have had crystals developed in their mass.

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According to competent observers all volcanic products are crystalline; even lava, taken from a flowing stream and quickly cooled, shows this structure when submitted to the microscope. The geological description of a rock or mineral, therefore, is but half done without a microscopical and chemical examination. In illustration of his paper Mr. Young exhibited sections of basalt, greenstone, claystone, pitchstone, slate, limestone, lava, and various other rocks.

The following papers were read by Mr. JAMES THOMSON, F.G.S. :— 1. "On the teeth of *Pleurodus*."—Mr. Thomson exhibited a slab of the Airdrie blackband ironstone, measuring 3½ by 2 inches, one of the surfaces of which, covered with shagreen, contained upwards of 65 teeth, belonging to what have hitherto been regarded as three distinct species of carboniferous fishes, viz., *Pleurodus Rankinii*, *P. affinis*, and a *Helodus;* but from sections prepared, which were shown under the microscope, and from investigations which he had made regarding the teeth and dermal structure of some of the living rays to which they are allied, he was of the opinion that the three varieties of teeth on the slab all belonged to one species only. 2. "Note on the Discovery of Plants in the Silurian schists of Argyllshire"—Mr. Thomson exhibited specimens of two different plants which he had discovered in a dark-gray arenaceous shale, near Campbeltown, which in that district forms a parting between bands of a bluish-gray crystalline limestone. One, marked with longitudinal parallel lines, resembles the *Sigillaria*, the other the *Calamites* of the coal measures. Mr. Thomson said he believed these plants to be the first traces of organic remains yet recorded from the Silurian schistose rocks of Scotland; and, as the bed in which he had found them had been observed in other localities in the West Highlands in a similar position to that in which it occurred near Campbeltown, he expressed a hope that future researches would reveal further examples of this ancient flora. 3. "On the Spines of *Ctenacanthus*."—The author stated that, so far as he was aware, the spines of *Ctenacanthus*, originally described by Agassiz, had never been described as associated with other head-parts, such as teeth or dermal covering. Recently, however, on slabs of the Airdrie blackband ironstone he had found the spines of this fish associated with the teeth of *Cladodus*, evidently in their proper relative positions, and in some of the same slabs were pieces of shagreen, which he had little doubt also belonged to the same fish. Embedded in the shagreen were a number of the so-called teeth of *Diplodus gibbosus* and other similar organisms, which he now felt satisfied were not teeth at all, but the dermal tubercles of *Ctenacanthus*.

The discussion upon the interglacial age of the Crofthead deposits near Neilston, on the line of the new railway to Kilmarnock, in which the remains of the Horse, Irish Deer, and *Urus* were recently found, which was postponed from last monthly meeting, was resumed by Mr. ROBERT CRAIG, who stated that the only points brought to light beyond those mentioned in his paper were :—1st, That the bones of the Horse were not found at the same spot as the skull of the *Urus* and the horns of the Deer, but were obtained in the north-eastern end of the cutting, near the face of

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the glaciated trap which had closed in the waters of the old lake. Their position in the laminated beds was, therefore, from ten to fifteen feet lower than the horizon on which the other remains were found, so that the horse had been entombed at an earlier period of the old lake's history than either the *Urus* or the Irish Deer; 2d, That from a series of bores put down since the recent great slip, at various points in the valley eastward of the boss of boulder clay, to ascertain the thickness of the laminated beds, the interesting fact had been revealed that there were several narrow intercalations of stony clay in the midst of the laminated beds similar in colour and composition to the upper stony clay covering the deposit in certain parts of the section. That these strips of stony clay were former slips of the lower boulder clay from the steep slopes of the hillside lying above the level of the old lake seemed, therefore, to be self-evident. Whether the upper stony clay overlying the deposits is a more recent slip from the hillside, or belongs to the so-called upper boulder clay of the country, he considered it to be a comparatively recent formation, and that the whole evidence was opposed to the supposition of its ever having been left in its present position by the melting of a second sheet of glacier ice passing along the valley.

Mr. JOHN YOUNG stated that since the last meeting he had twice visited the Crofthead section, on one of the occasions along with Professor Young, the President, and Mr. David Robertson. They had examined the section carefully, and satisfied themselves—1st, That there is no good evidence for supposing that there are two sets of glacial striæ—an older and a younger—upon the rock-face at the north-east end of the cutting, as believed in by some. All the striæ observed they would refer to the grinding of one ice-sheet, which had moved down the valley from south-west to north-east, glaciating the rock-surface, and probably depositing the lower boulder clay of the Cowden Valley; 2nd, That the recent slip from the steep hillside on the northern edge of the old lake has revealed that the lower boulder clay had formed the ancient shores of the lake, and is seen to rise against the rock-face to higher levels than the laminated beds. At one point, where the lower Till had slipped away from the rock-face, it was seen to be weather-worn, and not glaciated. It was also observed that the laminated clay, where it abuts against the lower Till on the northern edge of the site of the lake, is seen to be full of stones, which rapidly decrease in number as the bed is traced inwards. These stones have evidently been derived from the lower boulder clay, and carried out thus far into the fine laminated clay by the surge or lapping of the waves on the steep shores of the lake. Mr. Young believed that the origin of the upper stony clay could be best and most naturally explained by former slips of the lower boulder clay from the higher levels of the steep hillside. The fact that that which formerly covered the deposits at one or two points in the valley was not the first slip is now clearly proved by the narrow tongues or strips of stony clay found intercalated with the laminated clay. The crumplings and twistings seen in the laminated beds, which had been attributed to the pressure of the second or last ice-sheet, are more likely to have been produced by these slips impinging with great force under or over these beds, or they may, as

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Professor Young has suggested, have been produced by a creep of the lower boulder clay lying under the laminated beds upon the shores of the lake away from the steep rock-face, which creep, as it moved to the lower levels of the lake, would crumple and contract the laminated beds as far as the movement extended. In favour of this view, Mr. Young stated that the recent great slip has been produced by the cutting of the railway line through the valley nearly in the centre of the old lake. The surface beds, removed to a certain extent along the line, had increased the weight of the laminated beds resting upon the lower boulder clay on the inclined slopes of the valley. The consequence therefore is, that with the late rains the whole of the deposits, including the boulder clay, on the north-eastern portion of the valley, have slipped forward on towards the railway line, and still keep slowly moving away from the underlying rock-face. The crumplings in the laminated beds could not be due to the passage of an ice-sheet over their surface at a later period, because, in a photograph taken when they were best exposed, they are clearly seen to be overlaid by others which show no crumplings whatever, which would not have been the case if they had been caused by the passage of a glacier. They were, in Mr. Young's opinion, due to slips or "*creeps*" of the boulder clay before the upper laminated beds of the lake were deposited.

Mr. MAHONY, in his remarks, pointed out that the difference of opinion regarding the Crofthead section was now reduced to the question—Is the stony deposit overlying the laminated beds for a distance of 200 yards true boulder clay? Mr. Craig had arrived at the conclusion, after careful examination, that it was not the result of slips from the hillside, but that it was a deposit lying in its natural position. Thus, then, it must have been laid down either by land-ice or by water. The latter theory would require a post-glacial submergence of this valley under the sea. The former would explain better the chaotic nature of the deposit and the presence of glaciated stones. Although the bed was much less coherent than the lower Till, yet that did not, *per se*, remove it out of the category of boulder clays. He referred to other evidence showing the extreme antiquity of the lake beds and their contained fossils, and concluded by expressing his opinion that the original view was as tenable as ever.

JANUARY 13, 1870.

Mr. JOHN YOUNG, *Vice-President*, in the Chair.

Mr. R. R. Horne, Mount Vernon Colliery, Tollcross, was elected a resident member.

Mr. JAMES THOMSON read a paper on "Further Evidences of the Existence of Plant-remains in the Silurian Schistose Rocks of the West Highlands." Mr. Thomson referred to the paper which he had read at the previous meeting, in which he had laid before the members an account of his discovery of plant-remains in the schists of Cantyre, and the views therein expressed regarding the probability of their occurrence in other parts of the West Highlands, which he had now been able to confirm by having found frag-

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ments of wood in a conglomerate, composed of talcose schist and rounded pebbles of quartz, in Glencoe, where it occurs intercalated between beds of schist, which overlie the granite of the district. The pieces of carbonized wood do not exceed an inch in length, by about one-eighth of an inch across, and it was suggested by the Chairman that they ought to be submitted to a chemical and microscopical examination, in order that their true vegetable character might be accurately determined—a view concurred in by Dr. Bryce, who expressed his opinion that before geologists would be satisfied of the correctness of the discovery, a careful survey ought to be made to ascertain the true geological position of the conglomerate, and the succession of the associated beds.

Mr. THOMSON also read a paper on "The Vitrified Forts of Dunskaig and Carradale in Kintyre." He described the form of these forts, and drew attention to fragments of charred wood which he had found embedded between the angular pieces of the schistose rocks of which they are built. The walls of each of them are about six feet thick, and on examination he had found that they were only vitrified half through. Externally the rocks were quite altered in their crystalline structure, while the inner margin does not appear to have been affected by the heat at all. It was evident, therefore, that the forts had been vitrified by means of the wood found embedded among the stones, and that it had also been applied along the inner boundary only.

Mr. D. CORSE GLEN read a paper on the "Zeolites which occur in the Trap Rocks in the neighbourhood of Glasgow," illustrated by a large collection of these interesting minerals from the author's cabinet, consisting chiefly of *Analcime*, *Natrolite*, *Stilbite*, *Heulandite*, *Chabasite*, *Laumonite*, *Thomsonite*, *Prehnite*, etc. These minerals are all aluminous hydro-silicates, and their analysis has found them to consist chiefly of silica, alumina, lime, soda, potash, and water. They are found most plentifully in the trap rocks at Bowling, Kilpatrick, Port-Glasgow, Kilmalcolm, Fereneze, and Gleniffer hills. Several of them were first discovered in these districts, and named in honour of local mineralogists; *Thomsonite*, after the late Thomas Thomson, Professor of Chemistry in the University: *Edingtonite*, discovered by the late Thomas Edington, of the Phœnix Iron Works, near Kilpatrick, in 1823, and *Greenockite*, after Lord Greenock, now Earl Cathcart, who first found this rare and beautiful mineral in the Bishopton Tunnel in 1842. Some of the *Analcimes* and *Prehnites* which occur in the trap of Boylestone quarry, near Barrhead, are coloured by the copper which exists in a native state in the same rock, some examples of which were exhibited. Several specimens of the rare and valuable *Greenockite* were shown, which, although only about one-tenth of an inch across, are well formed and typical crystals. It is a sulphuret of the metal *Cadmium*, has a beautiful yellow lustre, and is pyramidal in form. This mineral has not been found anywhere except in the trap at Bishopton, the only known specimens having been obtained during the cutting of the tunnel, and from its great rarity is much prized by mineralogists, £20 having been paid for good crystals. An interesting specimen of *Thomsonite* from Magdala was exhibited, obtained by a soldier during the late Abyssinian war.

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FEBRUARY 3, 1870.

Professor JOHN YOUNG, *President*, in the Chair.

Messrs. Thomas Fletcher, 37 Bath Street, and Henry Morrison, 56 Cadogan Street, were elected resident members.

In conformity with the new rules adopted at the meeting of 2nd December, 1869, that in future the officers be elected at the ordinary meeting on first Thursday in February, in place of in October, as heretofore, the election was proceeded with, and on the motion of the Rev. John F. Potts, seconded by Mr. R. R. Horne, the officers elected on 7th October last were re-appointed for one year.

Mr. ALEXANDER DREW exhibited specimens of vitrified conglomerate from the neighbourhood of Oban. The spot where he had found them is in a bay, a short distance north of the entrance of Loch Etive, and is believed to be the site of Berigonium, an ancient British town. The stones are by some considered to be the remains of a vitrified fort, and by others to be of volcanic origin. The district around Oban is composed of slate rocks, overlaid by sandstone conglomerate, very generally capped by trap, which extends from Loch Melfort, on the south, to the spot where the vitrified stones occur. The slate-rock there again appears under the conglomerate, and on the top of a remarkably isolated table of about 40 feet in height, 100 in breadth, and 300 in length, of irregular shape, and rising abruptly from the shingle of the sea-beach, the supposed ruins of the vitrified fort are found. These are, however, mere hummocks and small knolls, composed of conglomerate of the same character as that found in great abundance in the neighbourhood, and showing no evidences of design; and Mr. Drew was therefore of opinion that the petrified appearances were not the artificial productions of man, but remains of the conglomerate at its northern edge, where it had been acted upon by a trap overflow, or was itself a lava or volcanic breccia.

The PRESIDENT delivered an address on the "Physical Configuration of Scotland, and its Influence on the History of the People."

MARCH 3, 1870.

Mr. EDWARD A. WÜNSCH, *Vice-President*, in the Chair.

Mr. John Meekin, florist, Partick, was elected a resident member.

Mr. THOMAS BARCLAY exhibited pieces of the branches of silicified trees, which he had collected for the Society's museum during a recent visit to Lower Egypt. They were obtained in the neighbourhood of Cairo, where there exists the remains of an extensive forest, which, during the tertiary period, had become submerged; and the vegetable matter having decomposed slowly, its substance had been replaced by silex, with which the waters had been charged. The specimens displayed the vegetable structure as perfectly as in the original plant.

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Mr. JOHN YOUNG read a paper "On the occurrence of the remains of Carboniferous Fishes in certain thin beds of indurated shale lying between sheets of trap, composing the Kilpatrick range of hills at Auchentorlie, near Bowling." Mr. Young stated that the shale bed containing the fish remains was exposed in the summer of 1867, during the cutting of a footpath upon the hillside in Auchentorlie Glen. His attention was first directed to this shale by the late Mr. Alexander Currie, of Bowling; and in one of its layers he had since discovered scales, teeth, and coprolites of at least two genera of carboniferous fishes—*Palæoniscus* and *Amblypterus*. It crops out upon the hillside at an elevation of 600 feet above the sea-level, being on nearly the same geological horizon, and lying between the same beds of trap as the seam of peaty coal and shale beds formerly discovered by Mr. Currie, and described by him a few years ago in the Society's Transactions. Mr. Young referred to the satisfactory evidence afforded by the discovery of these coal and shale beds in clearly establishing the carboniferous age of that long chain of trappean hills which stretch along the north-western border of our coalfield from Ardrossan to near Stirling. He said that a great deal of interesting geological phenomena remained still to be noted along this range, and urged upon the members of the Society a careful examination of all the beds of sedimentary strata and volcanic ash that may be found throughout the various districts separating the great sheets of trap, in order to ascertain if they contained any other organisms whereby their exact age in the carboniferous series might be more definitely settled.

Mr. YOUNG made some verbal remarks "On a supposed old River Channel buried under recent Drifts, extending westwards from Kilsyth to the Clyde." He stated that the result of the investigation of a large number of mineral bores, obtained by Messrs. Croll and Bennie, of the Geological Survey of Scotland, went to establish the former existence of a deep rock-basin or trough lying in the carboniferous system, which extended eastwards from near Bowling, on the Clyde, through the Kelvin valley to Grangemouth, on the Forth, whose bottom at one point, at Drumry, in that division of the basin which lies westward of the water-shed at Kilsyth, is 230 feet below the present sea-level; and in the eastern division this deep trough enters the valley of the Forth, at Grangemouth, at the greater depth of 260 feet. Mr. Young said that he would confine his remarks to the western division of the basin, viz., that extending from Kilsyth to the Clyde, for the purpose of showing that this deep trough could not have been scooped out by river-action, nor could have entered the Clyde at Bowling, and from thence downwards continuously to the sea at a depth of more than 200 feet below the present sea-level, as Mr. James Croll supposes, and whose views are given in a paper recently published in the "Proceedings of the Edinburgh Geological Society." In Mr. Croll assuming that this deep trough, which extends along the course of the Kelvin valley, and also up the valley of the Clyde to above Glasgow, was scooped out by river action, he seems to have lost sight of the fact that on both sides of the river Clyde, extending from near Erskine Ferry to below Bowling, the trap rock comes close to the shores of the river along this tract, narrowing and forming the comparatively shallow bed of the channel which the Clyde Trustees have been engaged

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deepening for years. This sunken trap ridge of carboniferous age at Bowling is a continuation of that forming the Kilpatrick and Renfrewshire range of hills. Mr. Young next pointed out that this low ridge of rock would form a barrier across the Clyde valley at this point; and if, as Mr. Croll supposes, the land then stood some 200 or 300 feet above the present sea level, he (Mr. Young) could not see how the waters of the Clyde, into which the Kelvin, Cart, and other streams flow, could ever have reached the sea outside, until they reached the height of the lowest portion of the rock-barrier at Bowling; nor could the sea, even at a later period, ever have obtained access into the upper reaches of the Clyde eastward of the barrier until this rocky ridge was depressed under sea-level, which was probably during the glacial period, in which there is evidence, from the marine shells found at Paisley and elsewhere, that marine conditions prevailed in reaches of the Clyde eastward of the barrier as far up the river as Glasgow. At present, this barrier at Bowling has been reduced, by erosion and man's agency, to a depth of from 20 to 30 feet below the level of the river, but it must be at least still 200 feet above the bottom of the deep rock-basin which stretches eastward up the Clyde and Kelvin valleys, as revealed by the bores. Mr. Young showed that this rock-basin, previous to its being filled up by recent sediments, must have existed as a deep lake, whose waters stood on a level with that of the barrier, just as the present barrier at the mouth of Lochlomond determines the height of its waters above that of the sea. Mr. Young further stated that a river flowing westwards from the watershed at Kilsyth along the valley of the Kelvin would, supposing it could be cleared out of its present surface deposits, have only to run down a sloping channel to the depth of 110 feet, when it would have entered this great lake, whose bottom at many places was more than 300 feet below the level of the above watershed, and whose waters, while the land stood higher, would always be on the level of the barrier at Bowling. After mentioning a number of other points in connection with this assumed buried river channel, Mr. Young recommended the members to read the papers of Messrs. Croll and Bennie, so that the subject might be fully discussed at a future meeting of the Society.

APRIL 9, 1870.

Professor JOHN YOUNG, *President*, in the Chair.

Mr. G. B. M'Nair, and Mr. C. B. Dixon, 18 Ashton Terrace, were elected resident members.

Mr. JAMES GEIKIE, Vice-President, read a letter addressed to him by Mr. James Croll, of the Geological Survey of Scotland, with reference to some remarks recently made by Mr. John Young on a paper entitled, "On Two River Channels Buried under Drift," &c., contributed by Mr. Croll to the Transactions of the Edinburgh Geological Society. In this letter Mr. Croll said that in his paper he had stated that the deep hollow which he (Mr. Croll) had every reason to believe was the ancient bed of the Kelvin,

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was ascertained by a bore at Drumry to be no less than 230 feet below the present sea-level, and that for several miles to the east and west of this place it was nearly as deep. Consequently, if this hollow was an old river channel, it must enter the Clyde somewhere near to Bowling, at a depth below the present sea-level of upwards of 200 feet; and, "if so, then it followed that the rocky bed of the ancient Clyde must be buried under more than 200 feet of surface deposits from Bowling downwards to the sea." Nothing was inferred by Mr. Croll regarding what may have been the condition of the Clyde above Bowling, consequently Mr. Young's objections, grounded upon the supposition of a rocky barrier crossing the Clyde below Erskine Ferry, had absolutely nothing to do with the question at issue. Mr. Geikie then made a few remarks, stating that he had visited the localities mentioned in Mr. Croll's letter, and found that Mr. Young, in his recent remarks, had made some mistakes. Mr. Young had stated as a fact, "that on both sides of the river Clyde, extending from Erskine Ferry to below Bowling, the trap-rock comes close to the shores of the river along this tract, narrowing and forming the comparatively shallow bed of the channel, which the Clyde Trustees had been engaged deepening for years." Now, it was not the case that trap rock occurred in the bed of the Clyde at Erskine Ferry, neither did it come close to the shores of the river at that place, so as to narrow the channel; and as no rock was met with between this point and the sea, it was quite gratuitous to assume that the river flowed over a shallow rocky bed. Neither in bores nor in dredgings had anything save mud, sand, clay, and gravel been met with in the channel of the Clyde between Erskine Ferry and Bowling. The fact was that the hill only approached close to the river at Bowling, and even here there was sufficient room between the lip of the river and where the rock appeared on the southern shore for a broad river channel to lie buried. Mr. Geikie had protracted the slopes of the hills at Bowling, and found that, by continuing the angle formed by the inclination of the hills on both sides, we could not have a less depth than from 250 to 280 feet of drift deposits lying in the centre of the valley at this place. This result fully bore out the conclusions arrived at by Mr. Croll in his paper; for, as Mr. Croll had said in his letter, any question concerning the condition of the Clyde above Bowling was immaterial and irrelevant. Mr. Geikie then went on to say that the only place where rock actually occurred in the bed of the Clyde was at Elderslie, near Renfrew Ferry. Mr. Deas, resident engineer to the Trustees of the Clyde Navigation, had kindly allowed him to inspect the charts and bores in his office, and from these it was apparent that at Elderslie the river flowed for a short distance upon rock. This rock was part of a bed of dolerite intruded among sedimentary strata of carboniferous limestone age, and Mr. Young was wrong in supposing that it belonged to the trappean series of the Kilpatrick and Renfrewshire hills. The mere fact of rock crossing the river at Elderslie was no proof whatever for the existence of any such rocky barrier as that imagined by Mr. Young. The alluvial and drift deposits stretched far away to the south and north of Renfrew Ferry, and all over that broad haugh-land no rock appeared. Now, before Mr. Young's "barrier of rock" could be received as a fact, he would have to prove that

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the rock got in the Clyde at Elderslie stretched continuously at the same level till it abutted against the high ground to the north, and he would require also to show that it extended, in like manner, all the way till the high ground near Paisley were reached. This he had not done, and could not do. The fact was, that a number of bores, put down between Elderslie and Paisley, showed that the average depth of the alluvial and drift deposits, overlying the solid rock, was more than 100 feet, and the depth of the same deposits, in the haugh-land to the north of Elderslie, was something similar. Thus, if we could strip away these superficial deposits from the basin of the Clyde, we should find that the rock, over which the river flows at Elderslie, was actually the top of a hill, overlooking a valley on the north and a valley on the south, in which latter, probably, would be seen the ancient course of the Clyde. Mr. Geikie, however, did not attempt to point out the precise course of the ancient Clyde. If that were ever traced out, it would possibly be found to rejoin the line followed by the present river somewhere about Erskine. If a sufficient number of borings were made between the river at Renfrew and the rising ground approaching Paisley, he had little doubt but that some of them would drop into the ancient channel of the Clyde. But, however that might be, we had sufficient proof that the "barrier of rock" mentioned by Mr. Young as stretching continuously across the valley of the Clyde, and which, to be a "barrier" at all, would require to keep the same elevation as the rock encountered in the bed of the river, does not exist. In conclusion, he protested against asserting as facts what were impressions suggested by uncertain data.

Mr. JOHN YOUNG, in reply, explained that the main point of his former remarks had been to establish that Mr. Croll, in the map attached to his paper, made the channel of the Kelvin open into the Clyde at Bowling as a deep river gorge, whereas he (Mr. Young) contended that neither the Clyde nor Kelvin could have flowed continuously to the sea through a deep gorge in the line of the indicated channels at a depth of more than 230 feet below the present level of the sea. Regarding the statement of Mr. Geikie that there are no barriers of trap or other rock across the Clyde above or at Bowling which could shut in the waters of the Clyde and Kelvin so as to prevent them getting to the sea at the depth above mentioned, Mr. Young said that he had made some inquiries of parties who knew the ground intimately as to the nature of these barriers, and they assert that the first or highest barrier of trap goes right across the river at Elderslie. Mr. James Thomson had also stated, on the authority of the party who blasted the barrier, that it was found from borings to extend both north and south of the channel of the river, it being part of a large trap bed extending across a considerable tract of country. Mr. Young considered that Messrs. Croll and Geikie had failed to point out, either on the north or south side of the present channel, any deep rock-gorge sufficient to drain the old lake basin extending up the Kelvin and Clyde. Again, the evidence from the borings put down below Paisley and this portion of the Clyde, where there is a large tract of comparatively level land, is that the old lake bottom shallows somewhat rapidly in this direction. Indeed, he considered that if a buried river channel ever had any existence, it could not have been over the line of

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ground indicated by Mr. Croll, and concluded by repeating his former statement that the bedded traps of the Bowling hills and those at Erskine do come close to the shores of the Clyde, and were once continuous across the present channel, and that it had not been proved that they had been cut throughout continuously to a depth equal to that of the old lake bottom, while the land stood at a much higher elevation.

POSTSCRIPT BY MR. JOHN YOUNG.

[As it is not my wish that my objections to Mr. Croll's views should rest upon my statements alone, I am now glad to be able to say that since the period when the above remarks were communicated to the Society, I have received from various individuals, who know the district and fully understand the importance of the subject under discussion, testimony as to the existence of barriers of trap across the Clyde valley, both in the shape of intrusive dykes and interbedded traps; also a more correct knowledge of the various places where they are to be seen, has come into my possession, my former remarks being chiefly statements made from memory. As my objections were based principally on the existence of tracts of trap-rock crossing the valley of the Clyde near Bowling, and which would shut in the waters of the Clyde, Kelvin, and other streams from getting through a river channel as deep as that indicated by Mr. Croll, and not upon any of the other points so ably put forward against Mr. Croll's views, by Mr. D. Milne Home in his recent work,* I shall confine my remarks to the evidence I have obtained of the existence of these barriers. That these dykes and other tracts of trap have long been known to persons familiar with the district, I have, in the first place, to refer for confirmation of the fact to an interesting M.S. essay in the Hunterian Museum, "On the Geology of the Shores of the Frith of Clyde from Glasgow to Garrochhead, in Bute." This essay is accompanied by a very good geologically coloured sketch-map of the district, and was written in the summer of 1836. The writer, a student of the University of Glasgow, is unknown, the essay being only accompanied by a motto. From his descriptions it is evident he must have examined for himself most of the ground to which the essay refers. At page 116, the writer says, when speaking of trap dykes within the district :—

"One principal dyke deserves to be particularly noticed. This dyke, it has been said, may be first seen amongst the trap in the parish of Kilmalcolm. Whether this be true or not, it is certainly not impossible, for trap dykes very frequently cut the trap rocks themselves. It may be distinctly seen somewhat further east, in the hilly parts of Houston parish, above Barrochan. Here it juts out above the surface of the ground, which it continues to do to a considerable height at various places, through the coal formation eastward, as on the farms of Craigend, Craigton, Gladstone, Ditch, Glenshinnoch, and Boghall Mains. At last it reaches the Clyde at Rashilee, in the parish of Inchinnan, where it is quarried on an extensive scale. Crossing the Clyde, although no longer so conspicuous, it may be traced, it is said, until it joins the trap of the Kilpatrick hills.

* The Estuary of the Forth and Adjoining Districts, viewed Geologically, pp. 87 to 96.

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Not the least interesting circumstance connected with this dyke is that at Rashilee, in the parish of Inchinnan, where the dyke reaches the Clyde, it is no longer a single dyke, but two dykes running parallel to each other, and each of them, before the quarries were commenced, standing about twenty feet above the surface of the ground.

"The dykes at Rashilee are each more than 100 feet in breadth, and about 120 yards apart. How far they continue in this form is uncertain; they reach at least to the diluvial hill of South Barr, but beyond that only one dyke is known to exist. The greenstone of the dykes at Rashilee is very fine grained. They have cut through the surrounding strata without much altering their inclination." The same writer, in speaking of the bedded traps of the district, says, page 62:—"The shore of the Clyde, also, in Kilmalcolm and Erskine parishes, is formed of it from the termination of the red sandstone near Newark Castle to the limits of the coal formation near Erskine."

Recently, Mr. John Burns, Glasgow, and Mr. Hugh M'Phail, Nitshill, who is conversant with the district, have conjointly examined the ground described in the essay. Mr. Burns informs me that they found the trap, and carboniferous strata by which it is flanked, rising to the surface at so many places, and with the distance so short between the various points, as to preclude the idea of any former channel of the Clyde having ever existed between its present course and the Renfrewshire hills. They also found trap coming to the surface at various places along the south shore of the river, from opposite Bowling to Rashilee (Erskine House being situated upon one of the bedded traps), and at other points where the new Geological Survey map has it coloured as Alluvium.

Mr. Robert Craig, Langside, near Beith, and Mr. James Russell, mineral surveyor, Chapelhall, who had both independently examined the ground for minerals long before this question under discussion was raised, informed me that they were surprised that Mr. James Geikie, in his statement in support of Mr. Croll's views, should display such a want of knowledge of the district as to assert "that the only place where rock actually occurred in the bed of the Clyde was at Elderslie, near Renfrew Ferry," while it is known to exist at other points in the bed, and on the shores of the river from Elderslie to below Bowling. Both of these competent observers testify as to the continuity of the dykes of trap that run between the Clyde and the Renfrewshire hills, as well as to the absence of all indications of an older channel of the Clyde south of its present course.

As it is not at all probable that these persistent dykes of trap, which cross the Clyde at Rashilee, nearly at right angles to the river, should there terminate, after crossing such a broad tract of country to the south, I have endeavoured to find traces of their existence on the north side; but the country is so completely mantled over by boulder clay and other drifts, that I have failed to find any signs of their appearance above ground. The only evidence I can offer, as to their extension into the country north-east of the Clyde, I give on the evidence of Mr. Kerr, who has long been River Superintendent, and has had charge of the blasting of the trap in the bed of the river at various points above Bowling. He kindly informed me that the

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dykes at Rashilee extended into the country north-east of the Clyde, as had been proved by boring. This being the case, they would consequently cut Mr. Croll's supposed channel of the Kelvin in its course to Bowling. He also informed me that the Clyde Trustees were so anxious to get quit of the trap in the bed of the river, that, if they could have got deep alluvial ground, either to the north or south of the present course, they would have made a diversion of the channel; but bores proved the trap to be continuous.

In the New Statistical Account of the Parish of Campsie, mention is made of a great greenstone dyke, which crosses the country from north-east to south-west. The writer says that south-westward its course has been observed at several points in the Campsie and Kilpatrick districts, and that it crosses the Clyde into Renfrewshire. This dyke would also cut the supposed channel of the Kelvin in its course; yet we see at the Milton of Campsie, where the Glazert—a more powerful stream than the Kelvin, above Kirkintilloch—crosses the dyke, that it has failed to cut a channel for itself much below the ordinary level of the valley. I am fully aware, as Mr. Croll states in his letter, that in his paper he did not infer anything as to the condition of the Clyde above Bowling; but surely the fallacy of any hypothesis must be obvious, which would give the small and sluggish stream of the Kelvin power to scoop out so deep a channel as that supposed, while we have evidence that the Clyde, with its much greater volume of water, flowing to the sea over the same tract of carboniferous strata, has failed to cut its channel in some tracts much below the present sea level. Neither have we any evidence, in any former period of the Clyde's history, that it ran in any other widely different course towards the sea than that in which it runs at present.

Having recently gone several times over the tract of country indicated as the supposed course of the Kelvin on Mr. Croll's map, I can find nothing in the surface configuration to favour the idea that the Kelvin flowed any further westward than in its present course. The country, from the flanks of the Kilpatrick hills down to the lower levels of the Clyde, is deeply covered with long undulating mounds of boulder clay and more recent drifts, ranged generally from north-west to south-east. Scattered over the district I noticed great numbers of ice-borne West Highland rocks, as well as more local boulders. The whole of the evidence, as far as I can see, points to the Clyde, Kelvin, Cart, and other streams having flowed into a wide, deep lake-basin, previous to the laying down of the sediments by which it is now filled up. One branch extended up what is now the Clyde valley to the eastward of Glasgow; the other and northern branch, which was probably the deepest, extended up what is now the Kelvin valley to near Kilsyth. That the present rivers scooped out this lake-basin I do not believe; for at its lower end, above Erskine and Dalmuir, where the harder traps rise to the surface, bores put down to the coal measures across this tract show that its bottom is more than 100 feet less deep than some points up the Kelvin valley to the eastward; whereas the bores ought to have shown (if the basin was scooped out by river action) that it actually deepened towards the outlet.

Mr. James Geikie, in his remarks, when speaking of the tract of trap which crosses the Clyde at Bowling,—the breadth of which can be best

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estimated by those who have travelled by railway to Greenock, where it may be seen extending from near Bishopton tunnel to beyond Langbank,—says, "that by continuing the angle formed by the inclination of the hills on both sides, we could not have a less depth than from 250 to 280 feet of drift deposits lying in the centre of the valley at this place." It is well known that the method by which he arrives at this conclusion does not hold good in every case, and that the depth of the sea or lake does not always depend either upon the slope or height of the hills bounding the shore. The depth of the rocky bottom of this narrow reach of the Clyde at Bowling is, therefore, a mere conjecture; for all that we know, or all that the Clyde Trustees seem to know, is, that the rock does not interfere with the navigation of the river, as it does further up. Drifts to the depth of 250 feet are not warranted by any facts which have come before us, from what we know of the low angle at which the rock dips under the water from the low, flat terraces on each shore. In concluding these remarks, I have only to state, that further evidence will be given in the paper of Mr. John Burns—"On the Surface Geology of the Clyde Valley"—as to to the existence of trap in the bed of the river; the information being partly obtained from the maps of the Clyde Trustees, kindly furnished by the resident engineer, Mr. Deas, and allowed to be inspected by this Society.]

Mr. D. Bell then read a paper entitled "Aspects of Clydesdale during the Glacial Period." (See page 63.)

The Chairman conveyed the thanks of the meeting to Mr. Bell for his interesting and suggestive paper.

Mr. John Young exhibited specimens of the finely laminated clay from the high green at the College, containing the tracks of certain organisms, and pointed out its thickness and extent under the north-eastern portion of the city. Mr. Young stated that during the last twelve months this clay has been extensively cut into by the railway operations now in progress. During all that time he had watched, from day to day, the excavation of the clay, in order to ascertain if it contained any traces of animal or vegetable life, and had washed several pieces of it, but had failed to detect either the shells of Mollusca, Entomostraca, or Foraminifera. Mr. David Robertson had also washed pieces of it, but had found only a few small seeds of plants. Recently he (Mr. Young) had detected, between the layers of certain portions of the clay, the tracks of at least three kinds of animals, the most numerous being small, narrow, plicated, thread-like tracks extending along the clay from one to three inches. A much larger plicated track he had found, which must have been of considerable length, the specimen preserved being nine inches long, but imperfect at either end. The foldings of this track are three-fourths of an inch wide. The other tracks consist of narrow lines of small oval impressions, about one-eighth of an inch apart, extending in nearly a straight line along the clay for about three inches. Mr. Robertson, who had examined these tracks, was of opinion that some of them may have been produced by annelids, others by small insects or crustaceans; but in the absence of the organisms themselves, it would be unwise to speculate as to their true character, or whether the clay was of fresh-water or marine origin.

The Society adjourned till the first Thursday in October.

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SUMMER EXCURSIONS—1870.

*April 23.—GLENIFFER BRAES. Mr. JAMES THOMSON, F.G.S., Conductor. Train to Paisley at 1.30. Beds of greenstone and volcanic ash; uptilted carboniferous limestone.

†May 7.—HIGH BLANTYRE. Mr. JAMES ARMSTRONG, the Secretary, Conductor. Train to Blantyre at 1.30. Newfield and Broom-house quarries. Sections of boulder clay, carboniferous sandstone, limestone, and shales, the latter rich in fossils.

May 14.—AUCHENREOCH GLEN. Mr. JOHN YOUNG, Conductor. Train to Bowling at 1.30. Lofty sections of Ballagan beds, trap dykes, veins of gypsum, old red sandstone.

May 26.—BALMAHA. Mr. ALEXANDER DREW, Conductor. Particulars as to train, &c., were announced in *Herald* of day previous.

The last of the Saturday afternoon excursions of this Society took place on Saturday, 14th May, to Auchenreoch Glen, on the Strathleven grounds, under the guidance of Mr. John Young, of the Hunterian Museum, one of the Vice-Presidents of the Society, permission to visit the glen having been kindly granted by Mr. Murray, factor on the estate.

The afternoon was showery, with glimpses of sunshine intervening, but perhaps the glen could not have been visited by geologists under more favourable aspects, as the rain brought out with greater distinctness the various colours of the numerous thin-bedded strata which form the lofty sections in its upper parts, while the banks, clothed with a profusion of early spring flowers, brightened with the delicate tints of green of the newly-opened foliage of the trees, now refreshed by the rain, imparted a beauty and freshness to the scene as only can be witnessed in such glens in the early months of summer.

The strata exposed in Auchenreoch Glen belong to the lower division of the carboniferous system. The group is of considerable thickness, and is found to extend over a large tract of country, having been traced along the north and south-western border of the Scottish coal field, from the hills behind Greenock, north-eastward along the flanks of the Kilpatrick, Campsie, Strathblane, and Fintry hills, nearly to the town of Stirling. The beds are very persistent in their character, and are easily recognised in their various localities wherever they appear. They consist of numerous alternations of thin-bedded nodular limestones, dark-grey and purplish grey marly shales, and have at the base and top a series of grey and whitish-coloured flaggy sandstones. The limestone bands, although nume-

* For an account of this district, see Report of Excursion on May 12, 1866. Trans. Vol. II., p. 169.

† See Trans. Vol. II., p. 170.

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rous, form but a comparatively small thickness of the whole strata, few beds exceeding one foot. They contain from 12 to 18 per cent. of magnesia, but are not worked at present for any economic purpose. From the typical section of these beds displayed on the hillside at the Spout of Ballagan, near Strathblane, the group is best known to geologists as the "Ballagan Limestone Series," and are of great geological interest, as affording one of the finest examples of stratification to be observed in this district of Scotland. In Auchenreoch Glen, and along the whole of the south-western flank of the Kilpatrick Hills, these beds, which dip to the south-east, are extensively developed, and cannot be less than many hundred feet in thickness. In ascending the glen section after section comes into view, each clearly marked by numerous thin bands of limestone. The banks also increase in height up to that point where the stream divides into several branches, each of which has cut for itself a deep ravine, in which the beds are very well displayed. At one or two points the strata are seen to be cut through by several narrow trap dykes, one of which, in the Murroch Burn, which flows into the glen on its eastern side, projects as a wall from the banks on each side of the stream, and forms a kind of natural gateway, known as the "Gates of Sodom," while a curious isolated pinnacle of trap—a fragment of another dyke—which rises from the bed of the burn a few yards further up, is known as "Lot's Wife." These masses of trap owe their present form solely to their being harder than the surrounding strata, resisting thereby, to a greater degree, the erosion of the mountain stream.

In the shales of Auchenreoch Glen thin veins of crystallised fibrous gypsum, of a fine white colour, varying in thickness from one to two inches, are found at several points, lying parallel to the strata, beautiful specimens of which were obtained by the members. A short search was made for fossils, but nothing organic was found, except a portion of the stem of a well-marked species of plant in one of the grey flaggy sandstones at the base of the group, this being the first known occurrence of plants in the strata of Auchenreoch, but the same sandstones have yielded to members of the society, on previous occasions, a few scattered scales of ganoid fishes.

The "Ballagan" group is singularly devoid of fossils, a few plants only having been obtained at the "Spout of Ballagan" and the Corrie of Balglass on the Fintry Hills, in grey sandstones similar to those which occur in Auchenreoch Glen. The series in this glen, as well as in other localities, where the base of the group is seen, is found to rest conformable to the underlying Old Red Sandstone. One point noticed by the members before leaving was the singular absence of boulder clay, or other drift, lying upon the hillside in the upper parts of the glen. Only at one or two points on the ascent was any boulder clay observable overlying any of the sections. Where it did occur, the contrast in colour was very striking, the boulder clay derived from the wearing down by ice of the Old Red Sandstone to the north-west being of a brick-red colour, while the underlying shales of the "Ballagan" series are of a dark grey. Erratic boulders of West Highland rocks are, however, common on the hillsides, and throughout the district, great numbers being seen in the bed of the stream.

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Annual General Meeting, October 6, 1870.

Professor John Young, *President*, in the Chair.

ANNUAL REPORT BY THE COUNCIL.

The Council beg to report on the condition and work of the Society during the past Session.

Membership.—The Council urges the appeal made by the Treasurer, not merely because an accession of members is financially required, but because the enlargement of our roll is the best proof that the Society can give of its efficiency in the diffusion of the love and knowledge of the science.

Library.—The Librarian has reported during the Session the receipt of many valuable additions, partly by gift, partly by donation.

Ordinary Meetings.—The ordinary meetings have been conducted with the same success as in former Sessions. The exhibition of specimens by members has been a very important part of the business, and the Council thinks it right to remark, that to this the Society owes very much of its success, since the remarks with which the display of specimens are accompanied, and the discussion to which they give rise, render what at first might appear a subordinate matter, the means of conveying much valuable instruction. The papers read were of great interest, and their number gives hope that the ensuing Session will be as fruitful in contributions. The success which attended the course of lectures on subjects in Elementary Geology warrants the Council in recommending a repetition of the course; and the Syllabus now in the hands of members shows that they have secured already the co-operation of several gentlemen who have kindly undertaken to summarise the present knowledge in various branches of Geology and Palæontology. There are many difficulties in the way of establishing what is much needed in Glasgow, viz., a systematic course of Evening Lectures on Geology; and the Council has, with much regret, been obliged to decline acceding to the request addressed to it that it should undertake the organisation of such a course. But, in drawing the attention of the Society to the subject, the Council will point out, that, to secure the safe establishment of an authoritative course, the co-operation of some such body as the Directors of the Andersonian University is required, and it feels justified in pledging the Society to give its utmost aid in promoting such an object.

Excursions.—The method adopted last Session of arranging at every meeting for an excursion on the following Saturday was eminently successful. The Society has thereby acquired more of the character of a Field Club than it formerly had, and while no great numbers may have attended any one, the total number at all was very good. Moreover, to junior members no better opportunities could be offered of studying the structure of the adjacent district in detail, and with reference to the principles of Geology.

Election.—The election of Office-bearers has now been remitted to our February meeting. But the Council regrets that one vacancy has occurred, which must be filled up this evening. Mr. Armstrong desires to be relieved from his office of Secretary, and the Council regretfully feels obliged to accept his resignation. Mr. Armstrong has wrought long and well on

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behalf of the Society, and is thus in some measure entitled to ask relief, though the fact, at the same time, increases the difficulty of replacing him. The duties of Secretary have been performed during his term with very great energy, and the success of our meetings is very largely owing to his efforts. To these laborious, and often, it must be confessed, troublesome duties he has added the preparation of a Catalogue of the Library, at the same time superintending the system of exchanges with other Societies, which he has developed to a very high degree. The Museum has also received much of his care and labour; while, as Editor of your Transactions, since their commencement in their present form in 1864, and Reporter of our Proceedings, he has placed us under a heavy debt. While accepting, therefore, of his resignation, the Council would ask the Society formally to record its acknowledgement of his services, and the regret with which his retirement is received.

The Council has ascertained the willingness of two gentlemen to undertake the duties of the Secretaryship, subject to the approval of the Society. The division of the office is now required because of the many duties now devolving on the Secretary, which can only be performed by one person at a sacrifice of time it is unfair to ask from an unpaid official. Believing that personal enthusiasm is of more value than accurate routine work, the Council has much satisfaction in recommending Mr. Bell and Mr. Burns as Joint-Secretaries.

The Secretary regrets that the Transactions are not ready for issue, because of the delay in receipt of several papers read last Session, and he hopes the volume will be ready before November.

Museum.—No important additions have been made to the Society's Museum during the past year, and the Council mentions this with regret, because it believes that, for the purpose of Elementary Classes, a rich Museum is indispensable.

Mr. Dugald Bell and Mr. John Burns were elected Joint-Secretaries of the Society in room of Mr. James Armstrong, who retires from office.

Mr. James Armstrong and Mr. Æneas M'Master were elected members of the Council, in room of Messrs Bell and Burns, the newly elected Secretaries.

The President made a lengthened criticism on Mr. Catlin's work on the "Lifted and Subsided Rocks of North America." A discussion followed, in which Mr. John Young, the Rev. Mr. Williamson, and others took part, and a vote of thanks was tendered the President for his valuable critical observations.

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PROCEEDINGS FOR THE YEAR 1870-71.

NOVEMBER 3, 1870.

MR. JOHN YOUNG, *Vice-President*, in the Chair.

Rev. WILLIAM LEGGAT, Messrs David More, C.E., Thos. Johnston, C.E., William Wyper, Robert Hutcheson, James Neilson, James E. Wilson, Peter Dewar, David Murray, William Ker, and Robert Balloch were elected resident members.

Mr. JAMES THOMSON, F.G.S., submitted to the society some remains of Fish and Brachiopoda which he had recently discovered in the neighbouring coal fields, and which were new at least to the west of Scotland. These were *Acanthodes Wardii*, from the Palace Craig Iron Stone, Carnbroe, near Airdrie; *Athyris pisum*, from Brockley; and *Anomia corrugata*, from Dalry. He pointed out the characteristics of these species, and described the relative position of the beds in which their remains had been found.

1. The *Acanthodes* was a well-preserved specimen, showing the dorsal and anal spines in their natural position. This was of some importance, as these spines had frequently been found singly, and could not be referred to any known genus; but this discovery enabled palæontologists to name and classify these ichthyodorulites. This species had also been discovered in the Staffordshire coal field by Mr. John Ward, and named by Sir Philip Egerton, F.R.S., after its discoverer. It also occurs in the Edinburgh coal field. The specimen before them had been found near Airdrie, in the upper members of the Clyde coal measures.

2. *Athyris pisum.*—This little fossil occurs at Brockley, Lesmahagow, and Roughwood, Ayrshire. From its resemblance to *Terebratula saculus*, it had often been mistaken for that shell; but when placed under the microscope the structural characters indicated that it could not be referred to that genus. It had been submitted to Mr. Thomas Davidson, F.R.S., who named it *A. pisum*, from its pea-like form.

3. *Anomia corrugata.*—This is the first well-authenticated specimen of *Anomia* that has been recorded from the Scottish carboniferous limestone. It is found in a band of shale which underlies the "Linn" limestone, near Dalry.

Mr. YOUNG followed with some remarks, and conveyed the thanks of the meeting to Mr. Thomson for his interesting communication.

Mr. D. C. GLEN, C.E., gave some notes on the boulder clay laid open in the excavation now going on for a new dock at Cartsdyke, near Greenock, and referred to the abundance of arctic marine shells, and other organisms, found embedded in it. The shell bed seems to occur in a hollow of the boulder clay, which has been exposed to view by a deep cutting running

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parallel to the river, or east and west. On the northern side of this cutting, nearest the river, the bed is several feet in thickness; but on the other side it thins out, and finally disappears as we recede from the shore. In the other direction, from east to west, it is seen to abut suddenly against the boulder clay, and thus occupies a hollow of no great extent, in which, however, an immense number and variety of marine organisms are crowded together, forming one of the richest beds of such clay yet discovered on our western coast. At the same time, there was reason to doubt whether the deposit is now found in its natural position, or has not been dug out from some neighbouring part of the shore, and laid down to improve and level the ground, many years ago, in forming the grounds where the excavation is being made. On this point, however, he would not express a decided opinion, and other members who had visited the spot were not unanimous regarding it.

Mr. YOUNG said the section of boulder clay and the shell bed referred to were of great interest, and he hoped would receive a careful examination from the members of the Society. He alluded to the number of large boulders, found principally in the upper portion of the deposit, the majority being sandstone of local origin, and the remainder granite, trap, and schist from more distant localities. Many of these boulders were beautifully smoothed and striated by the action of ice. With regard to the puzzling features presented by the shell clay—the way in which the shells are huddled together, the absence of any distinct stratification in it, and the manner in which it abuts suddenly against the boulder clay on either hand —these circumstances, together with its being of a looser texture, or less firmly compacted than most of the arctic shell beds found on our coast, undoubtedly suggest that it has been disturbed and removed. On the other hand, he read a note from Mr. David Robertson, whose opinion in such matters was entitled to very great weight, pointing out that a thin bed of fine clay, in which marine organisms occur, extends continuously between the shell bed and the underlying boulder clay—which seems opposed to the supposition of the shell clay having been laid down on an old land surface. Apart from this point (Mr. Young added), the deposit is worthy of attention as being exceedingly rich in organic remains, about 140 species having been already obtained from it, including some rare and many well-known arctic forms.

An arranged series of these shells, polyzoa, &c., was exhibited by Mr. Young and Mr. Glen. Several other members also remarked on the deposit, and arrangements were made to revisit the locality at an early date.

DECEMBER 1, 1870.

MR. JOHN YOUNG, *Vice-President*, in the Chair.

Mr. James Blair, 5 Richmond Street; Mr. John Fyfe, 32 Candleriggs; and Mr. D. M'Arthur, 26 Bothwell Street, were elected resident members.

The CHAIRMAN exhibited a block of carboniferous sandstone from

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Gilmorehill quarry, about nine inches in thickness, showing in that space 32 well-defined alternate white and dark-brown stripes, which gave the specimen a beautifully stratified appearance. Mr. Young stated that the brown stripes were due to the particles of sand having become mixed with bituminous matter previous to their deposition. It was perhaps not easy to explain the alternation, so oft repeated, of these white and coloured bands, but he thought the stripes could not have been so clear and distinct if the sand had been impregnated with the colouring matter *after* deposition. The layers of white and brown sand had evidently been deposited as such, at irregular intervals, over the area in which this striped sandstone is found, and which, he might mention, is of very limited extent in the quarry he had named. He then referred to other bituminous sandstones found in the coal measures near Glasgow, and said he believed the bitumen by which they had become impregnated had been driven off by heat from other bituminous strata in their neighbourhood, and in some cases had been mixed with the sand during the deposition of the bed; in others had been carried into it at a later period by infiltration. As regarded the specimen before them, the former, as he had already indicated, was the more probable hypothesis. All these bituminous sandstones, on being burnt, lose their bitumen, and return to their normal colour.

Mr. Thomas Naismith exhibited specimens of the fine large teeth of *Rhizodus Hibberti*, from the ironstone pits at Possil; jaws, scales, and teeth of *Megalichthys Hibberti* and *M. rugosus*, besides a number of fin-spines and other fragments of fishes, from the Airdrie coal field; also portions of crania and vertebræ of Labyrinthodonts from the Quarter black-band ironstone.

Mr. D. C. Glen, C.E., laid before the meeting several slabs of oil shale from near Collingwood, on Lake Huron, Canada; and also some samples of the pretroleum distilled from it. The slabs were from the Silurian formation, which is of great extent in North America, and remarkable for the regular succession of its strata. When examined, these blocks of shale were found to be stratified horizontally with layers of Trilobites, Entomostraca, and other marine organisms. It was from the prodigious abundance of these creatures over this track of the ancient sea-bottom that the slabs now referred to had derived their bituminous properties.

The oil shown was distilled from the shale in the usual manner, by heated retorts. The pure, clear spirit is taken from the oil, leaving a thick residuum which is used for tarring outside work, and also for burning in steam-boiler and other furnaces. Another sample of oil on the table was pumped up from a bored well at Bothwell, C.W., where the oil occurs at a depth of from 100 to 500 feet from the surface. When pumped out, it is mixed with three or four times its bulk of salt water. It is then allowed to settle in large tanks, and when the water is drawn off from below, it leaves the oil in very much the same state as that distilled from the shale. In all probability, therefore, this oil is derived from a similar stratum, impregnated with organic animal matter.

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JANUARY 5, 1871.

MR. EDWARD A. WÜNSCH, *Vice-President*, in the Chair.

Mr. T. S. M'Ewan, 56 West Cumberland Street, was elected a resident member.

Mr. JAMES THOMSON, F.G.S., read a paper on the occurrence of *Cœlacanthus lepturus* in the Palace Craig ironstone at Newarthill, and *Palæoniscus Wardii* in the lower black-band ironstone at Possil. He briefly described the scales, fin-rays, and head-plates of *Cœlacanthus*, which had been found in a detached form in the neighbouring coal measures, and which the examination of a nearly entire specimen from the Staffordshire coal field had now enabled him to identify. It occurs in the upper members of the carboniferous system in Scotland, in a shale overlying the Palace Craig ironstone of the Airdrie coal field. Both with regard to this species and the *Palæoniscus*, he remarked that he had these forms for years in his cabinet, unnamed; and it was only recently that *Palæoniscus Wardii* had been described, and named after its discoverer in the Staffordshire coal field, Mr. John Ward, of Longton. It is found in the Possil ironstone, which is between four and five hundred fathoms below the position in which it occurs in Staffordshire, thus not only adding another form to the fauna of our Scottish coal fields, but adding also to our knowledge of its range in time. The lower beds of the Ayrshire coal field had also yielded some specimens of fossil.

Mr. THOMSON exhibited specimens of *Rhizodopsis sauroides*, *Amphycentrum granulosum*, and *Platysomus parvulus*, from the Staffordshire coal field, observing that the scales of *Rhizodopsis* had been found in our Scottish coal beds, but as yet no complete specimen of the fossil had thence been obtained.

Mr. THOMSON also exhibited specimens of *Oldhamia* from Bray Head, near Dublin. He described minutely the position of the beds in which these fossils are found, and complained that geological references are frequently so vague as to be of little real service to one going over the ground for himself. Two species of this fossil had been discovered (*O. antiqua* and *O. radiata*), and they were generally believed to have been zoophytes, allied to the *Sertularia*. Their precise nature, however, is still matter of discussion. They possessed a special interest as being, with the exception now of *Eozoon Canadense*, the oldest distinct traces that had been found of life on the globe. Mr. Thomson further called attention to the wide unconformability presented by the mountain limestone near Dublin, resting as it does upon the Cambrian rocks on the north, and upon the granite on the south side of the bay.

The CHAIRMAN conveyed the thanks of the meeting to Mr. Thomson for his interesting papers.

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FEBRUARY 2, 1871.

MR. JOHN YOUNG, *Vice-President*, in the Chair.

Messrs. John Ferguson, 94 Duke Street; Robert M'Callum, Cambuslang; Alexander M'Ara, 2 Oswald Street, and George Thomson, West George Street, were elected resident members.

The Society then elected its officers for the present session, and the Council was accordingly declared to be constituted as under:—

President—JOHN YOUNG, M.D., F.G.S., Professor of Natural History, Glasgow University.

Vice-Presidents—EDWARD A. WÜNSCH, JOHN YOUNG, JAMES THOMSON, F.G.S.

Joint-Secretaries—DUGALD BELL, 27 Lansdowne Crescent, JOHN BURNS, 91 Mitchell Street.

Treasurer—JOHN WIGHT, C.A., 150 Hope Street.

Librarian—THOMAS NAISMITH, 233 Duke Street.

Other Members of Council—JAMES ARMSTRONG, JOHN POTTS, JAMES DAIRON, D. CORSE GLEN, ARTHUR PRATT, GEORGE R. ALEXANDER, DANIEL WILSON, ÆNEAS M'MASTER, DAVID SANDEMAN, ALEXANDER DREW, ARCHIBALD ROBERTSON, JOHN ORR.

A collection of phosphates from Charleston, U.S., was exhibited by Mr. Potts and Mr. Naismith, together with some large fossil teeth, vertebræ &c., from the same locality. Mr. Potts stated that large quantities of these phosphates are being used in America, and also imported into this country, for the manufacture of artificial manures. The specimens on the table had been collected from some cargoes lately brought to the Clyde. The deposit from which they are taken is found along the banks of many of the rivers in South Carolina, and immediately under the surface soil of the land lying between; and is supposed to underlie a large portion of the coast and sea-island region of that part of America. It consists of layers, varying from six inches to several feet in thickness, of irregularly rounded nodules, mixed up with an immense quantity of bones—ribs, vertebræ, tusks—of various species of animals, all more or less petrified. The nodules yield 50 to 60 per cent. of bone phosphate; while from some of the bones as much as 80 to 85 per cent. of this fertilising substance had been obtained. The deposit, which only came into notice a few years ago, has already given rise to an important commerce both in the raw and manufactured article. Numerous companies have been formed in Charleston and its vicinity for phosphate digging and manufacture, and the planters have found the use of the manure, which is about one-third cheaper than guano, exceedingly profitable. The export of the raw material has also assumed considerable proportions; and altogether this remarkable deposit is contributing in no small degree to the prosperity of South Carolina and the neighbouring States. Immediately below the deposit is a bed of white limestone marl of great thickness, which has been recognised as underlying

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all the country round. Mr. Potts then read several analyses, which he had obtained of these phosphates, showing the high percentage of fertilising matter which they contained. He also called attention to the large size of some of the teeth and vertebræ exhibited. It was evident the deposit was of comparatively recent age; but the precise geological period to which it belonged, and the nature of the organisms of which it was composed, he would leave to be elucidated by others.

The CHAIRMAN said there could be no doubt this remarkable deposit of phosphates belonged to the *Tertiary* period, and probably its earlier division, the *Eocene*. The tertiary formation is largely developed along the southern coast of North America, stretching in a belt of considerable breadth from North Carolina to the Gulf of Mexico, and leaving the coast-line only at the delta of the Mississippi. The thick bed of limestone marl, which had been referred to as underlying the deposit, probably belonged to the immediately preceding formation, the *Chalk*, which is found in New Jersey and North Carolina, and crops out at intervals farther south, from beneath the tertiary strata, between the Appalachian Mountains and the sea. The deposits in Britain most closely resembling these Charleston beds are those known as the "Bagshot and Bracklesham beds," occurring in Surrey and Sussex. They belong to the *middle-Eocene* division of the tertiary, or more recent than the "London clay." They contain numerous remains of fishes, some resembling the sword fish, teeth of sharks of various species, bones of crocodilian forms allied to the gavial, and some that were considered to belong to an extinct order of huge serpents. The whole series of fossils, like those before them, indicated a much warmer climate than now prevailed in that part of the world, and showed that the waters of the sea were teeming with large and powerful forms of life. Some of the sharks' teeth found in these Bracklesham beds closely resembled those on the table from the Charleston deposit; but one or two of the latter, measuring about five inches long from root to point, and four inches broad, implied a species of shark of extraordinary magnitude, certainly not less than 60 feet in length. The largest living species, the white shark, sometimes attains a length of over 30 feet. Some interesting questions arose as to these thickly-strewn fossiliferous beds, which are found in all formations, restricted often to one particular "horizon," but they are due, no doubt, to the circumstance of the creatures whose remains are found in them having frequented certain banks or stretches of coast, as we find is the case with the marine animals of the present day. Mr. Young concluded by conveying the thanks of the meeting to the exhibitors.

Mr. ROBERT CRAIG, corresponding member of the society, read a paper "On the Boulders found in Cuttings on the Beith Branch Railway, considered in relation to their parent rock; with remarks on the local character of the Boulder Clay," (p. 45.)

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MARCH 2, 1871.

Mr. JOHN YOUNG, *Vice-President*, in the Chair.

Mr. E. A. WÜNSCH, V.P., read a paper "On a section of the Northern Shore of Arran," giving an account of some transported blocks of limestone which he had observed there during the previous summer. After describing the remarkable succession of deposits which had made that part of Arran classic ground for the geologist, he referred more particularly to a characteristic bed of limestone found near the "Salt Pans," on the north-eastern shore of the island. This limestone is of a deep-red colour, and is full of the shells of *Productæ*—especially *Productus latissimus*—together with fragments of *Encrinites* and other organisms. The bed is very regularly jointed, and breaks up into beautiful cubical masses. He had noticed several detached boulders and smaller fragments, down to minute pebbles, of this limestone at various distances along the shore, sometimes in sheltered bays, and as far as four or five miles from the parent bed. One block, of considerable size, to which at present he wished to call attention, he had observed a little above high-water mark, fully a mile from the original deposit, and within a quarter of a mile of the beds of volcanic ash which he had formerly described. It had been drifted, most probably by floating ice, over a massive ledge of sandstone and indurated shale intervening between it and the sea, and projecting above the general inclination of the shore. He had had this block overturned for the purpose of ascertaining what was beneath it, and whether any glacial shells or gravel different from that surrounding it might not be disclosed. In order to effect this, it was necessary to clear away the vegetation with which it was surrounded and partially overtopped. According to surface appearances, he expected the seaward end of the block would be found to present the same angle to the seashore as the opposite end; but, on obtaining a full view of it, and turning it over, he found that it presented a very different angle—that, in short, nearly a foot of the rock on the seaward side appeared to have been worn away since it had been laid down in that position. This point he illustrated by means of a diagram, showing that the block had been exposed obliquely to the action of the waves, and had lost about eleven inches on the exposed side. These blocks were so uniformly cubical in form, and were also so regularly stratified, that he entertained no doubt regarding the original shape of the one in question. From this he had derived a clearer idea of the actual tear and wear of the sea-shore than he had otherwise obtained. Mr. Wünsch concluded by calling the attention of students of geology to the great variety of boulders and pebbles scattered along the shore he had described, all of which could be identified with the parent beds—thus affording most instructive examples of the action of shore ice in a former colder climate, and of waves in more recent times.

The CHAIRMAN said there could be little doubt that the various boulders of Arran rocks found perched on the old raised sea-beach which fringes the coast of the island had been carried and dropped into their present position by coast ice, during the glacial period, when the island stood at a lower elevation than at present. Many of the boulders are of large size, and have been carried by drifting ice to various parts of the coast, distant from

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where the rocks occur *in situ*. On the melting of the ice these boulders were dropped at various elevations upon the submerged land, and can now be traced from the raised sea-beaches seawards in considerable numbers. Their presence on shore levels now above the sea, as well as the evidence of the raised beaches themselves, clearly attest the rise of the land in the West of Scotland in recent geological times. It might be remembered that Professor Ramsay, in his standard little work on Arran, long ago pointed out that many of these boulders, now considerably above the tidal level, rest not on their broadest and most solid part, but on their apices, as if, while they were within high-water mark, the action of the advancing and retiring waves had washed away the lower portion of the rock. The instance brought forward by Mr. Wünsch seemed to be one of a similar kind. Mr. Young then referred to the discovery of three new species of *Lepidostrobus* from that highly interesting bed of vocanic ash near Laggan, in which Mr. Wünsch had found so many plant-remains of lower carboniferous age. These Arran *Lepidostrobi*, along with five other new species from the coal fields of Scotland, had been worked out and determined by that able investigator of fossil botany, Mr. E. W. Binney, F.R.S., who, by his patient researches, had done so much to elucidate the structure and affinities of the carboniferous flora.

Mr. James Thomson, F.G.S., read a paper on the occurrence of *Stigmaria stellata*, Eichwald in the lower carboniferous series at Wildshaw, in the upper ward of Lanarkshire. He described the position of the strata in which these plant remains had been found—in beds of fire-clay and indurated sandstone, capping those thin bands of limestone which characterise the lower members of the carboniferous series in Scotland. The section at Wildshaw is the following :—

6 feet calcareous shale.
3 ,, hard light-greyish sandstone.
2 ,, fire-clay, containing portions of *Stigmaria*.
3 ,, highly-indurated sandstone, or chertzite, into which the *Stigmaria* roots passed.
11 ,, thin banded limestone, with partings of calcareous shale interstratified.

Mr. Thomson mentioned that remains of *Stigmaria stellata* were of comparatively rare occurrence in the Scottish coal field. He had only found it in two other localities, and always on the same geological horizon. In the under-clays of the Welsh coal beds they were more abundant, also in a similar positionin those of Nova Scotia. He pointed out that the *Stigmaria* were now generally admitted to be the roots of the *Sigillariæ*; but in this case he had found them associated and in contact with what some authorities had called *Korria taxina*. The specimens on the table presented very distinct stellate markings which had surrounded the rootlets at the base of attachment. He exhibited some prepared sections under the microscope, showing the woody structure of the pith, which, he remarked, bore a striking resemblance to that of the coniferæ. The excellent preservation of these plant-remains he attributed to the hard matrix in which they had been embedded. The sandstone seemed to have undergone a meta-

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morphic process of some kind, probably owing to volcanic agency, though he had failed to discover any trace of igneous rocks in the immediate neighbourhood.

Mr. YOUNG was of opinion that the highly siliceous sandstone in which these plant-remains had been found, and which is locally termed "kingle" in many of the coal districts of Scotland, may have derived the extra quantity of silica and lime which it contains from thermal springs holding these substances in solution, and impregnating the other sediments during deposition. He referred to several localities in the West of Scotland where beds of such siliceous sandstone or "kingle" occur, as well as bands and nodules of silica in the limestones; and said there was evidence that while these strata were being deposited, there had been, at no great distance, contemporaneous volcanic action. It was well known that silica was largely deposited around the hot springs of Iceland, as also in the Azores, and other places.

Mr. NAISMITH exhibited a series of large and well-grown specimens of *Balani* and *Lepadidæ* which had been taken from the bottoms of Clyde ships on their return from foreign voyages. He said these specimens might be considered to belong more properly to the Natural History Society; if so, he trusted their friends would excuse his trenching for once on their ground. If further apology were needed, he might add that the study of recent forms was the means of throwing light upon those which are extinct.

APRIL 13, 1871.

Mr. JAMES THOMSON, F.G.S., *Vice-President*, in the chair.

Mr. JOHN BURNS read a paper on "The Surface Deposits of the Clyde Valley." It was singular, he remarked, that, as the tertiary and post-tertiary beds were the last to be deposited, they should likewise have been the last to come under the special attention of the geologist. In 1839, the late President of this Society, Mr. Smith of Jordanhill, read a paper to the Wernerian Society on "The Elevated Marine Beds of the Basin of the Clyde." Up to that time scarcely anything in the way of tracing out the true history of these beds had been attempted. Since then, however, these hitherto neglected fields have been cultivated with great energy and success. During the last few years the deposits of the Clyde valley have had more minute and careful examination bestowed upon them than any similar deposits throughout the country. The labours of Messrs. Crosskey, Robertson, and Bennie have now made these the best known post-tertiary deposits of any in Scotland. The valley of the Clyde is bounded on either side by a range of hills several miles apart; but between these and the present river-bed there exists a series of terraces, which are evidently ancient sea-margins or beaches. These are very distinctly seen on both sides of the river, commencing at the Flesher's Haugh, and ascending step by step till on Springburn Road they attain a height of 189 feet, and at Langside on the south 190 feet. Having expressed his opinion that

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these successive levels were caused chiefly by changes in the bed of the sea, and not by successive elevations of the land, Mr. Burns remarked that the accumulation of these surface deposits could not be explained by any one agency. In one bed we find undoubted evidence of a lake deposit, in another of a salt water, and in a third of a running water deposit. The four distinct beds or deposits which are met with in the Clyde valley are sand, clay, mud, and gravel. Each of these represents a particular condition of deposition; and it was to be observed that these deposits range from 70 to 350 feet in thickness, as shown by bores put down in different parts of the basin. Mr. Burns then gave particulars of several bores from the neighbourhood of Glasgow, chiefly from Stobcross, in order to show the general arrangement of the beds. Most of these presented a great succession of beds of sand and gravel, and occasionally such beds interspersed with the boulder clay. The layers of sand and gravel found in the boulder clay he thought proved that the glacial period was not continuous in its duration, but that several warm periods occurred, during which the ice-sheet disappeared, and the usual water deposits overspread the boulder clay. In Ireland and England there seems to be an upper and an under boulder clay, the two being separated by great beds of sand and gravel, having in them shells of a less arctic type than those found connected with the true boulder clay. This proves that the break in the glacial period must have been of long duration. In the Kilmaurs district, shells of a true artic type are found beneath a great bed of boulder clay; and beneath these again is found a bed of peat. At the same time, he admitted that the great number of various layers and beds found in some of these bores, and the differences noticeable in those of the same locality, could hardly be accounted for by any agency which extended over a wide area; and he believed these were in many instances the results of local causes, particularly of changes in the ocean currents which transported and assorted the materials. In this way we might have a deposit of boulder clay or sand accumulating over an extended area, and these might afterwards be broken up and interbedded with other and different materials. The river deposits, and the clays containing the glacial shells are now pretty well known; but beneath these clays we find deposits of mud, occasionally, in some parts of the Glasgow and Paisley clayfields, more than 100ft. in thickness, in which no remains of life have been found. It would be rash, however, to conclude that these are entirely devoid of life. There is a good deal of difficulty connected with the study of these beds, as they are not exposed in many natural sections, and the small surface extent disclosed in boring operations is not a very sure guide for determining the presence or absence of life in any particular stratum. It is evident from these bores that the ancient surface of the Clyde valley was very irregular in its configuration, and presented very much the same appearance as its present scenery. In one part we find a high mound of clay or gravel, and in another a deep gorge or hollow filled with fine clay or sand, all indicating many changes in the mode of deposition as well as a difference in the character of the materials deposited. The laminated clays and the fine sands are evidently rewashes from the boulder clay. He showed two samples of fine sand, one being taken from a bed

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exposed at Stobcross, and the other washed by himself from the till—the two being exactly alike. In any body of moving water the heavier materials would first settle down, forming sands and gravels, until there was nothing left but the fine mud, which would gradually be deposited in deep hollows where the water was still and calm. In this way a bed of laminated clay may gradually extend into sand and gravel. The thin beds of mud, sand, and gravel which are so frequently seen in cuttings and excavations, he believed, were the results of some great inroad of water into the estuary, caused, most probably, by the giving way of banks or barriers of *debris* which had held back accummulations of water in the higher grounds. We might thus have in one part a bed of gravel extending over a great tract of country, in another a bed of sand, and in a third a deposit of finely-laminated clay. As soon as the flow of water had ceased, the usual deposits would again be laid down on the surface of the intrusive bed; and this might be of frequent occurrence. The fine sand which is met with throughout the whole valley, and which is void of life as far as yet known, must have been deposited in very deep water, and the various depths at which it is found show that it settled down on an irregular surface. The upper or river drifts, as shown in the Stobcross excavations, contain a great many fragments of decayed wood, hazel nuts, &c., and in many cases these have been encrusted with peroxide of iron, and all trace of the vegetable matter destroyed, so that only casts remain. This seems to be peculiar to an upper bed of brown sand, and must be due to some local cause. Throughout the whole of these river-drifts we find large quantities of coaly matter—sometimes in thin seams, mixed with the sand and gravel; at others in small fragments, often finely rounded like quartz pebbles. These show that during the deposition of these beds the carboniferous strata in the Upper Ward of Lanarkshire were being denuded, and fragments of them carried down by the stream, as at the present day. During these long ages of deposition the Clyde must often have changed its course, and in different parts we find undoubted evidence of such changes. A few years ago a narrow bed of gravel was exposed in the Trongate, which had every appearance of being an old river channel. The same kind of bed was found in St. Enoch Square, and latterly at Stobcross. After referring to the ancient canoes which, as was well know, had been dug up in and around Glasgow, Mr. Burns said that the different deposits throughout the Clyde valley all tended to show that the materials had been laid down in deep water, and that the whole estuary had been an inland sea, formed by barriers of rock running across the valley, and keeping back the waters in the same manner as the waters of Lochlomond are confined at the present time. He referred, in confirmation of this view, to the trap dykes and masses of bedded trap found at various parts in and near the river bed, as at Elderslie, Rashilee, and between Erskine and Bishopton. At Rashilee the trap was found standing side by side with the sandstone, and could be traced close to the river, and the *Productus* limestone was thrown to the surface to the south of the dyke. These barriers, he held, must have shut in the central valley, and dammed back the waters of the Clyde to an extent sufficient to account for the beds of fine sand and mud met with throughout the valley. He concluded by

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expressing his obligations to Mr. Duncan for enabling him to exhibit a deer's head and a collection of shells which had been dredged from the river; to Mr. Deas, for valuable assistance and information regarding the excavations at Stobcross; and to Dr. Fairless, of Bothwell, for some interesting specimens of marine clay from that locality.

Mr. JOHN YOUNG expressed his satisfaction at the confirmation which the views he had submitted to the Society on a former occasion regarding the bed of the Clyde had received in the latter part of Mr. Burns' paper.

Mr. BELL considered that was but a part of Mr. Burns' subject, and preferred looking at it as a whole. He questioned the accuracy of Mr Burns' deductions in some instances, and thought he had sometimes called into action more extraordinary agencies or conditions than were really required to account for the phenomena. He did not see, also, how some parts of his scheme could be made to hang together. There was evidently a good deal still to be done to make out a clear and consistent account of these surface deposits.

Mr. CRAIG, of Beith, was also inclined to doubt some of the conclusions which Mr. Burns had arrived at, particularly as to there having been a number of distinct "breaks" or intervening warm periods during the glacial epoch. He was aware this theory had the support of high authorities, but thought the evidence on which it rested was exceedingly slender.

The CHAIRMAN having made some remarks, chiefly with reference to the "rocky barriers," alluding to evidence he had obtained on the Duntocher side, that the carboniferious strata there rose so near the surface as to make the existance of a deep channel in that neighbourhood impossible, Mr. Burns briefly replied, and received a cordial vote of thanks for his paper.

APRIL 27, 1871.

Mr. JOHN YOUNG, *Vice-President*, in the Chair.

Mr. DAVID ROBERTSON, F.G.S., read a paper "On the Post-Tertiary Fossiliferious Deposit at Garval Park New Dock, Cartsdyke, with notes on other Post-Tertiary beds in the upper Reaches of the Clyde" (p. 32).

SUMMER EXCURSIONS—1871.

May 6.—DUMBARTON AND BOWLING. Train from Dundas Street at 1.30 p.m. Mr. JOHN YOUNG, Conductor.

May 13.—CRAIGENGLEN. Train to Bishopbriggs at 1.20 p.m. Mr. JOHN YOUNG, Conductor.

May 25.—WHANGIE AND SPOUT OF BALLAGAN. Omnibus from General Post Office at 9 a.m.

June 10.—AUCHENSKEOCH, near Dalry. Train from Bridge Street at 1.30 p.m. Mr. JAMES THOMSON, F.G.S., Conductor.

June 24.—GIFFNOCK. Train from South Side at 2.5 p.m. Mr. H. M'PHAIL, Conductor.

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ABSTRACT of the TREASURER'S ACCOUNTS of the GEOLOGICAL SOCIETY of GLASGOW, for Year ending 30th Sept., 1870.

REVENUE.

Cash in Secretary's hands at 1st October, 1869,					£2	5 4
Subscriptions—						
Year 1868-69 (Arrears), 7 at 10/,			£3	10 0		
Year 1869-70, 189 at 10/,		£94	10	0		
Less Arrears or resigned, 37 at 10/,		18	10	0		
		76	0	0		
New Members, 11 at 10/,		5	10	0		
					81 10 0	
					85	0 0
Petty Receipts,					0	12 0
Transactions sold,					4	5 0
Interest on Cash in Bank,					1	9 3
Drawn from Bank,					79	5 0
					£172	16 7

Balance due to Treasurer at 1st October, 1869,				£0	1 1
Printing Transactions—					
Volume III., Part II.,	£39	1	3		
Binding,	2	11	0		
				41	12 3
Binding Pamphlets,				4	1 6
Printing Cards and Circulars, 1868-69,	£6	7	0		
Do. Reprints of Papers and Lists of Members,	11	17	0		
				18	4 0
Magazines and Transactions purchased,				4	6 6
Subscription to Palæontographical Society,				1	1 0
Do. to Professor Sars' Family,				2	0 0
Delivering Circulars and Transactions,				7	6 3
Taxes, Insurance, and Advertising,				5	18 10
Stationery, Postage, and Carriages,				10	3 8
Petty Disbursements,				2	10 9
Lodged in Bank,				72	14 3
Balance due by Treasurer,				2	9 7
Balance due by Secretary,				0	6 11
				£172	16 7

STOCK.

Sundry Current Liabilities,				£20	0 0
Balance for Net Stock,				236	10 9
				£256	10 9

Cash in Bank—					
Deposit Receipt,	£27	14	3		
Current Account,	1	0	0		
				28	14 3
Cash in Secretary's hands,				0	6 11
Do. in Treasurer's hands,				2	9 7
Property—					
Library and Society's Publications,	£100	0	0		
Fossils and Minerals,	75	0	0		
Cases,	50	0	0		
				225	0 0
				£256	10 9

GLASGOW, *3rd Oct.*, 1870.—We have examined the foregoing Accounts, and compared the same with the Vouchers, and find them correctly stated and vouched, the Balance in Treasurer's hands at 30th September, 1870, being £2 9s. 7d., and in Secretary's hands 6s. 11d. sterling,

JAMES MACAULAY, } *Auditors.*
ÆNEAS M'MASTER, }

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LIST OF OFFICERS AND MEMBERS

At October 12, 1871.

MEMBERS OF COUNCIL.

President—JOHN YOUNG, M.D., F.G.S., Professor of Natural History, Glasgow University.

Vice-Presidents—EDWARD A. WÜNSCH; JOHN YOUNG; JAS. THOMSON, F.G.S.

Joint-Secretaries—DUGALD BELL, 27 Lansdowne Crescent; JOHN BURNS, 91 Mitchell Street.

Treasurer—JOHN WIGHT, C.A., 150 Hope Street.

Librarian—THOMAS NAISMITH, 233 Duke Street.

Other Members of Council—JAMES ARMSTRONG, JAMES DAIRON, D. CORSE GLEN, JAMES THOMSON, F.G.S.; GEORGE R. ALEXANDER, DANIEL WILSON, ÆNEAS M'MASTER, DAVID SANDEMAN, ALEXANDER DREW, ARCHIBALD ROBERTSON, JOHN ORR, J. F. POTTS, B.A., ARTHUR PRATT.

HONORARY MEMBERS.

Thomas Davidson, F.R.S., F.G.S., Brighton.
David Page, LL.D., F.R.S.E., F.G.S., Newcastle-on-Tyne.
Archibald Geikie, F.R.S., F.G.S., Director, Geological Survey of Scotland, Edinburgh.
T. Rupert Jones, Professor of Geology, Royal Military College, Sandhurst.
James W. Kirkby, Pirnie Colliery, Leven, Fifeshire.
Henry Woodward, F.G.S., British Museum, London.
Joseph H. M'Chesney, Professor of Geology, University of Chicago.

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HONORARY ASSOCIATES.

John Scouler, M.D., F.L.S., 108 Woodlands Road.
James Bryce, LL.D., F.G.S., High School, Glasgow.
Thomas Struthers, Academy, Larkhall.
James Croll, Geological Survey, Edinburgh.

CORRESPONDING MEMBERS.

Rev. William Fraser, Free Church Manse, Paisley.
T. B. Grierson, M.D., Thornhill, Dumfriesshire.
Rev. Dr. Gordon, Manse of Birnie, Elgin.
Rev. Dr. Paton J. Gloag, Manse, Galashiels.
Dr. John R. S. Hunter, Daleville, Braidwood, Carluke.
James Hunter, Ironmaster, Coltness Iron Works.
David Kerr, Wemyss Colliery, Fifeshire.
James Linn, Livingstone.
Rev. Alexander M'Bride, North Bute.
Rev. Hugh Mitchell, Craig, Montrose.
George Sommerville, Lennoxtown.
Alexander Winchell, Professor of Geology, University of Michigan.
Rev. Edward Myers, F.G.S., 20 Summerhill Terrace, Birmingham.
D. R. Rankin, Surgeon, Carluke.
William Grossart, Surgeon, Salsburg, Holytown.
Robert Slimon, Surgeon, Lesmahagow.
Robert Craig, Langside, Beith.
John Dougall, M.D., 115 Paisley Road.

RESIDENT MEMBERS.

Those marked * are Life Members.

Addison, James, Engineer, 532 St. Vincent Street.
Aitken, Robert J., 116 St. Vincent Street.
Alexander, George Russell, 11 Sardinia Terrace.
Allan, Archibald B., 3 Argyle Terrace, Queen's Park.
Armour, Andrew, 68 Anderston Quay.
Armstrong, James, 16 Albert Drive, Crosshill.

Balloch, Robert, 76 Wilson Street.
Bannerman, David, Corn Exchange Buildings, Hope Street.
Bell, Dugald, 27 Lansdowne Crescent, *Secretary*.
Bennie, James, 11 Prospect Street, Edinburgh.
Birrell, George, Iron Merchant, 62 Jamaica Street.
*Blackie, John, jun., 17 Stanhope Street.
Blair, James, 5 Richmond Street.
Buchanan, James, 36 London Street.
Burnet, John, Architect, 150 St. Vincent Street.
Burns, John, 91 Mitchell Street, *Secretary*.

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Cameron, William, Drayton Lodge, Brompton Road, South Kensington, London.
Carrick, John, City Architect, 4 South Albion Place.
Chambers, Henry, 85 Candleriggs Street.
Cochran, Hugh, 13 George Street.
Connal, Michael, Merchant, Virginia Buildings.
Colquhoun, Hugh, M.D., 17 Grosvenor Terrace.
Coghill, William, 263 Argyle Street.
Crawford, Ebenezer, Eagle Foundry, Port-Dundas.
Crawford, W. C., Eagle Foundry, Port-Dundas.
Crosskey, Rev. Henry W., F.G.S., 28 George Street, Edgbaston, Birmingham.

Dairon, James, 4 Garden Street.
Davidson, Robert, 33 Virginia Street.
*Dalglish, Robert, M.P., 28 St. Vincent Place.
Dewar, Peter, Cartcraigs, Pollokshaws Road, Shawlands.
Dilley, Henry, 30 Hope Street.
Dixon, C. B., 18 Ashton Terrace.
Drew, Alexander, 23 Royal Exchange Square.
Dunn, William, Coal Master, 2 Oswald Street.

Evans, Mortimer, C.E., 97 West Regent Street.

Farie, James, 8 Willow Cottages, Canonbury Road, London.
Faulds, Robert, jun., 61 Parliamentary Road.
Ferguson, Fergus, 16 Hope Street.
Ferguson, John, Teacher, 94 Duke Street.
Ferguson, William, F.G.S., St. Aidan's Terrace, Birkenhead.
Fergus, Andrew, M.D., 41 Elmbank Street.
Fisher, Donald, 194 West George Street.
Fletcher, Thomas, 37 Bath Street.
Foote, William, 189 Trongate.
Frame, James, Union Bank, 113 King Street, Tradeston.
Fyfe, John, 32 Candleriggs Street.

Gale, James M., C.E., Corporation Water Works, 23 Miller Street.
Gault, W., 41 Lower Green Street.
Geikie, James, Geological Survey of Scotland, Edinburgh.
Gilmour, Thomas, 4 Orchard Street, Partick.
Glen, D. Corse, C.E., Greenhead Engine Works.
Gordon, John, Architect, 175 Hope Street.
Gossman, Adam, 38 Cadogan Street.
Graham, Walter, 35 Rose Street, Garnethill.
*Graham, William, M.P., 70 Miller Street.
Grainger, Thomas, Gas Works, Partick.

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Gray, James, M.D., 15 Newton Terrace.
Gray, Andrew, 30 Bath Street.
Grant, James, 27 Douglas Street.

Hamilton, James, Architect, 113 West Regent Street.
Harrold, James, 105 Glassford Street.
Hinshelwood, Alexander, 233 Crown Street.
Hood, Walter, 2 Royal Exchange Square.
Horne, R. R., Mount Vernon Colliery, Tolcross.
Hunt, Edmund, C.E., 87 St. Vincent Street.
Hunter, Matthew, Manufacturer, 9 Cochran Street.
Hutcheson, Alexander, 119 Hope Street.
Hutcheson, Robert, at George Simpson's, 170 Hope Street.
Hutton, William R., Chemist, 77 Renfield Street.
Hull, Edward, F.R.S., F.G.S., Geological Survey, Dublin.

Johnston, Thomas, C.E., Gowan Bank, Nitshill.
Johnston, William, 78 Gordon Street.

Kerr, William, 27 West George Street.
Kirsop, John, 98 Argyle Street.
Knox, Adam, 17 Bellgrove Street.

Lean, Daniel, Manufacturer, Reid Street, Bridgeton.
Leggat, Rev. William, 71 Greenhead Street.
Lorimer, John, Merchant, 19 St. Enoch Square.

M'Ara, Alexander, 2 Oswald Street.
M'Arthur, D., 26 Bothwell Street.
M'Callum, Robert, Cambuslang.
Macaulay, James, 34 Renfrew Street.
M'Clelland, Andrew S., Accountant, 140 St. Vincent Street.
M'Donald, Henry, 158 George Street.
M'Ewan, T. S., 56 West Cumberland Street.
M'Ewan, William, 72 Waterloo Street.
*M'Farlane, George, C.A., 163 West George Street.
M'Glashan, John, 114 Candleriggs Street.
MacGregor, Alexander, Clydesdale Bank, Miller Street.
M'Laurin, D., 17 Rutland Place, Govan Road.
M'Master, Æneas, Canal Bank House, Port-Dundas.
M'Meekin, John, Florist, Partick.
M'Nair, C. B., 18 Ashton Terrace.
M'Phail, Hugh, Nitshill.

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Marshall, John, Writer, 168 St. Vincent Street.
Maxwell, Andrew, 88 Cadogan Street.
Miller, James, 185 Crown Street.
Miller, James, Rosebank Cottage, Cambuslang.
Miller, John (Messrs. James Black, Drew, & Co.), 23 Royal Exchange Square.
Miller, James, Dalmarnock Cottage, Dalmarnock.
Moffat, R. Carter, F.R.S.S.A., Chemist, Mechanics' Institute, Bath Street.
Moore, Henry, Mining Engineer, 49 West George Street.
Moore, William, Mining Engineer, 49 West George Street.
More, David, C.E., Broompark Cottage, Dennistoun.
Morris, Robert, Coalmaster, 2 Oswald Street.
Morrison, George, West George Street.
Morrison, Henry, 58 Cadogan Street.
Mossman, John, Sculptor, 83 North Frederick Street.
Murray, David, Writer, 13 Fitzroy Place.
Murray, W. F., 47 Garngadhill.
Murdoch, James Barclay, Langside.
Muir, George, 229 High Street.
Muir, G. W., 5 Walmer Crescent, Paisley Road.

Naismith, Thomas, 233 Duke Street, *Librarian.*
Napier, J. W., Coalmaster, 249 Renfrew Street.
Neilson, Richard, 110 John Street.
Neilson, James, 16 Whitevale Street.
Neilson, James, jun., 49 Whitevale Street.
Norman, John, Engineer, 9 Scott Street.

Orr, John, 392 Gallowgate.

Pennycook, C. H., 100 Montrose Street.
Potts, John F., B.A., 100 North Frederick Street.
Pratt, Arthur, 162 Hope Street.
Pratt, David, 80 Great Clyde Street.
Purnell, Henry, Engineer, 305 Parliamentary Road.

Rankin, William, 37 Jamaica Street.
Rattray, John, 94 Renfield Street.
Reid, John, Hyndford Cottage, Lanark.
Reid, J. G., 37 St. Vincent Crescent.
Robertson, Dr. James, Clydeside House, Renfrew.
Robertson, Archibald, Manufacturer, 25 Queen Street.
Robertson, David, 4 Regent Park Terrace, Strathbungo.
Robertson, John, 33 West Cumberland Street.
Robertson, Joseph, 110 John Street.

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Ross, Robert, Writer, 176 St. Vincent Street.
Rowan, David, Engineer, 52 St. Vincent Crescent.

Sandeman, David, 2 John Street.
Selanders, David, Corn Merchant, 27 Hope Street.
Simpson, George, Mining Engineer, 170 Hope Street.
Smith, J. P., C.E., 67 Renfield Street.
Smith, John, Mining Engineer, Stobbs House, Kilwinning.
Smith, George, 141 Cumberland Street, Laurieston.
Spiers, Douglas, M.D., 170 Sauchiehall Street.
Steven, John, 28 St. James Street, Kingston.
Stewart, James (A. S. Henry & Co.), 29 Royal Exchange Square.
Stewart, Thomas P., 29 Queen Street.
Stewart, James F., 15 Roselea Drive, Dennistoun.
Stokes, James, Greenfield Colliery, Shettleston.
Stevenson, A. C., 128 Ingram Street.
Steel, James, 1 Seton Terrace.

Taylor, William, Surgeon-Dentist, 144 Wellington Street.
Thomson, George, Merchant, 69 Ingram Street.
Thomson, James, F.G.S., 276 Eglinton Street.
Turnbull, J., Engineer, 96 Renfield Street.

Wallace, W., Gordon Street.
Walker, Robert, Surveyor of Taxes, 13 Queen Street.
Walker, Robert, jun., Manufacturer, 8 Ingram Street.
Walker, Robert, Union Villa, Helensburgh.
Watson, William West, City Chamberlain, County Buildings.
Welsh, Thomas, 540 St. Vincent Street.
Whitesmith, Isaac, Engineer, 29 Govan Street.
Whitelaw, Alexander, 55 Sydney Street.
Whitelaw, Thomas, Shields Colliery, Motherwell.
Wight, John, C.A., 150 Hope Street, *Treasurer.*
Wilson, James E., 64 Abbotsford Place.
Wilson, Daniel, 124 Renfield Street.
Wilson, Hugh, 53 Garscube Road.
Wünsch, Edward A., Merchant, 149 West George Street, *Vice-President.*
Wyper, William, 171 Pollokshaws Road.

Yeaman, George, M.D., 5 Windsor Place.
Young, George, 13 Hope Street.
Young, John, M.D., Prof. of Natural History, Glasgow University, 13 Hillhead Gardens, *President.*
*Young, John, Hunterian Museum, College, *Vice-President.*
Young, William, City of Glasgow Bank, Virginia Street.
Yule, John, Engineer, 23 Carlton Place.

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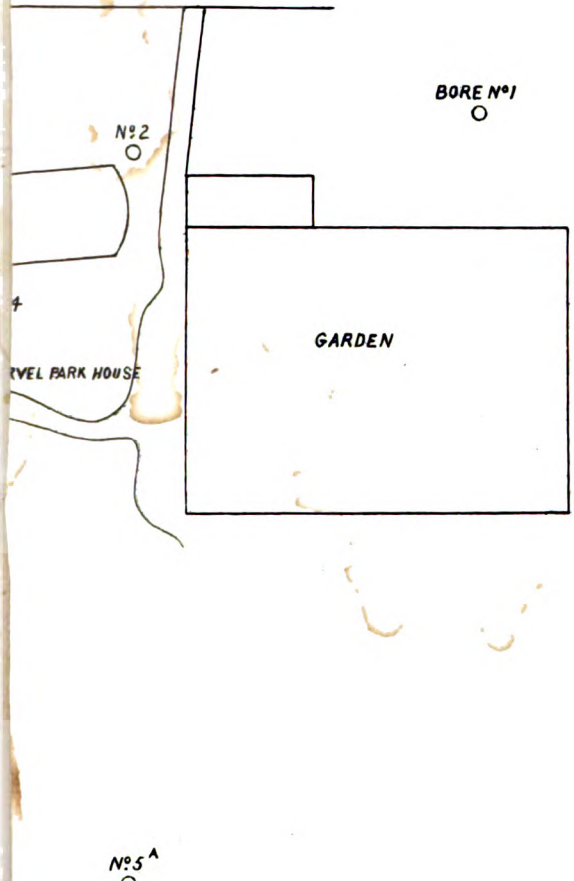
SKETCH

PLAN

SHOWING POSITION OF BOREINGS AT

GARVEL PARK.



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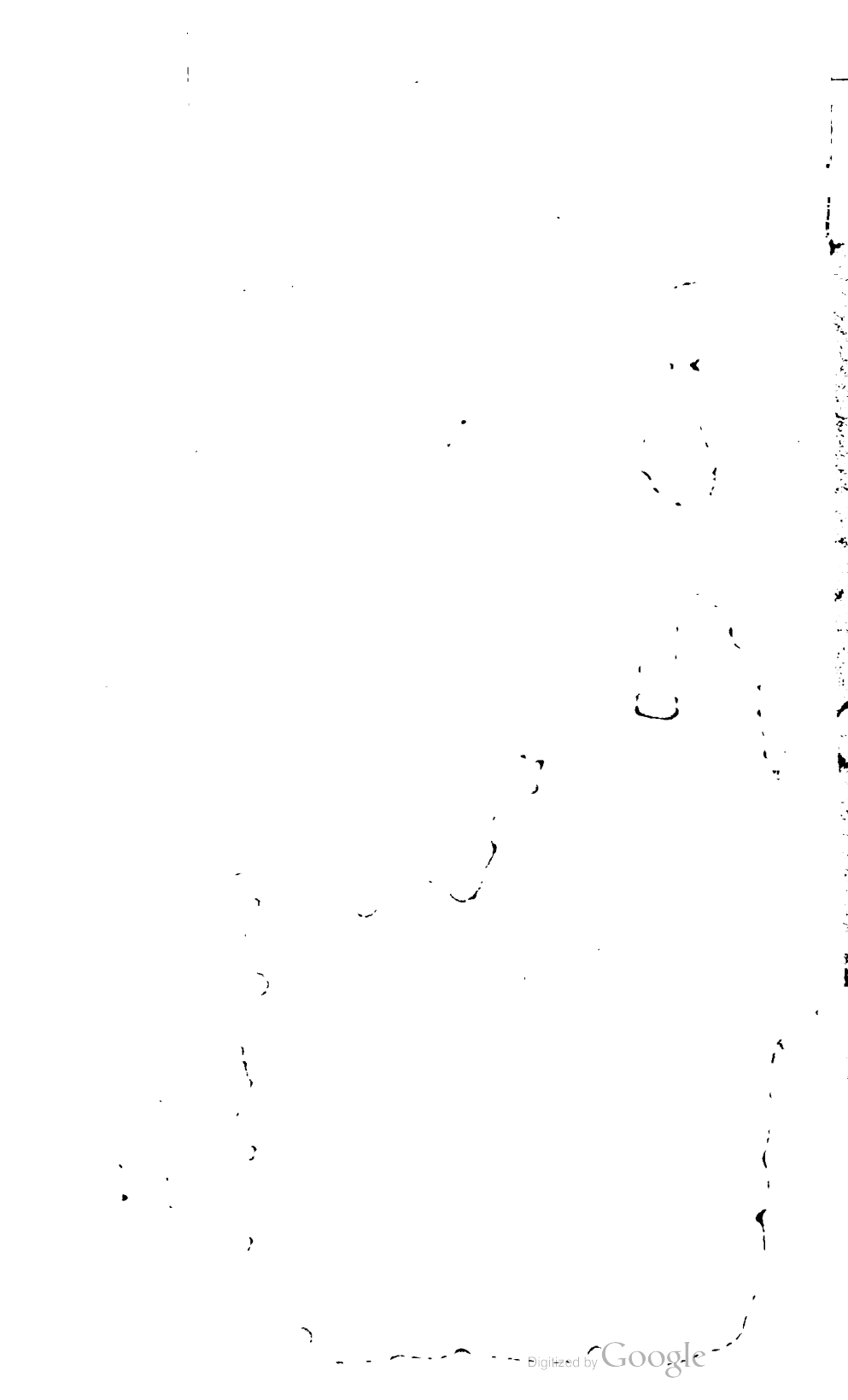
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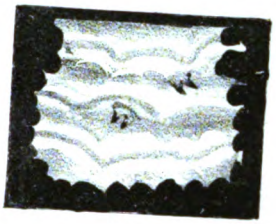

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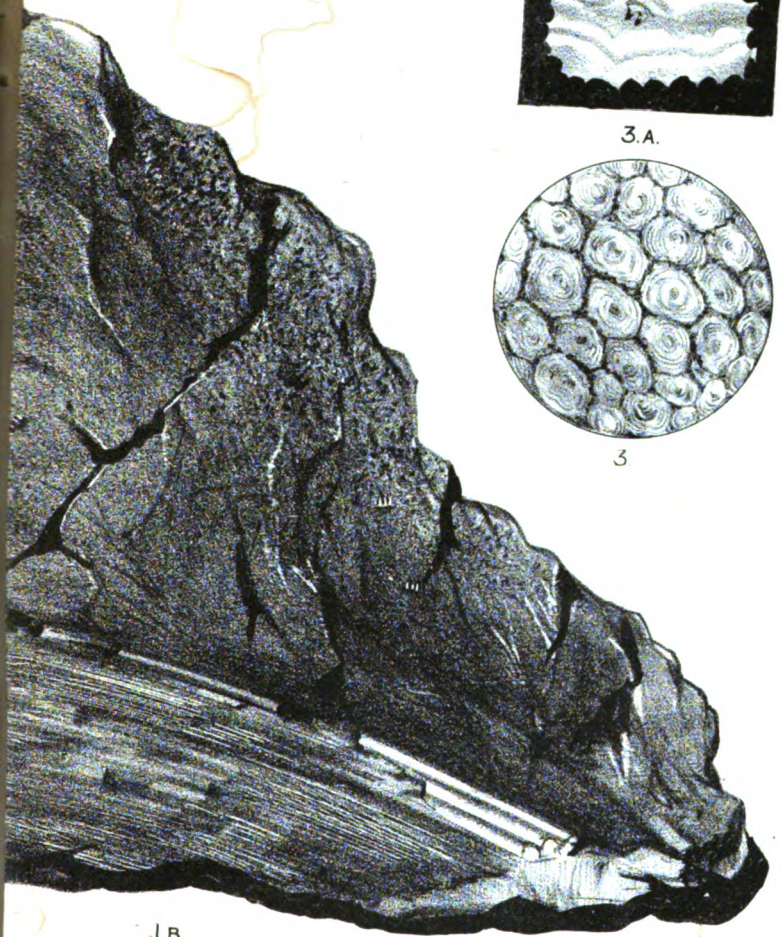

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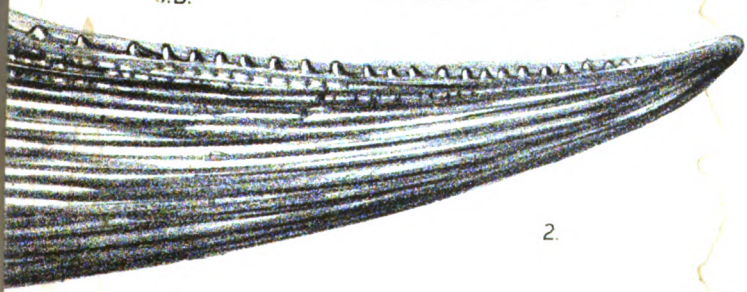

2.

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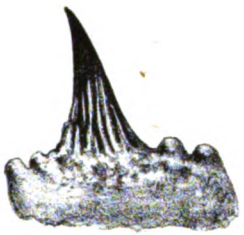

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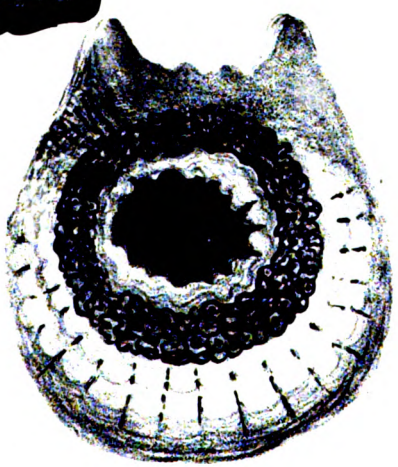

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW.

VOL. IV.—PART II.

PUBLISHED BY THE SOCIETY,
AT THEIR ROOMS IN ANDERSON'S UNIVERSITY BUILDINGS.
1873.

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The Editor begs to state that the Authors alone are responsible for the facts and opinions contained in their respective papers.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

VIII.—*Some Points in* Geological Terminology. *By* John Young, M.D., F.G.S., *Professor of Natural History, University of Glasgow.*

(Closing Address as President.—Read 8th February, 1872.)

The science of Geology is so popular that it is almost counted a discredit if any one errs in the use of its technical terms. Yet it is doubtful if the terminology of any other science is in the same state of uncertainty; and it is probable that in no other science should we find a leader prepared to advocate the propriety of terms being used in a somewhat loose sense. It may be a little troublesome, but it is always possible to follow the changes which take place in zoological notions, for the terms are very precise. New words have been, to a large extent, invented to represent particular views, or familiar terms are used with a careful restriction which protects them from abuse. But geological language, as distinguished from that of mineralogy, is that of ordinary life transferred without alteration. That there should be no definition of Coal is not surprising, even though the legal mind was greatly exercised thereby. But when we find no exact meaning attaching to Formation, Period, System, Contemporaneity, and when we find that something very like resentment is entertained towards palæontologist who shall be rash enough to advance views founded on the facts of his science, it is clear that some confusion exists as to the vaunted mutual aid of palæontology and geology.

But the confusion has not yet reached its maximum. The very definition of Geology itself is undergoing practical revision. It is long since it was established by Hutton as a science dealing with

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phenomena similar to or identical with those observable at the present day. At that time Geography was either a physical description of the earth's surface, or a series of details grouped from a political, ethnological, or antiquarian point of view. It was understood also to include the study of the earth's figure and motions, and of other cognate astronomical questions. Now Geology is divided between Geognosy, in so far as it deals with mineral character; Zoology and Botany, in so far as it records the varieties of animals and plants preserved in mineral masses; and Geography, of which it forms an integral part as a description of past earth-surfaces. Palæontology is in fact no longer a distinct science any more than Human Anatomy, Ichthyology, or, in Botany, Filicology and Lichenography. The palæontologist is a naturalist who makes a more or less special study of fossil forms. But, as the distribution of animals and plants illustrates, and is illustrated by, modifications of the earth's surface, the work of the palæontologist is (when not devoted to the systematic classification of the forms with which he deals) a contribution to geography; and the geologist, or he who maps out the characters, positions, and proportions of mineral masses at various places, is likewise a contributor to a more extensive science. Professor Ramsay has stated the relation in the title of his volume, "Physical Geology and Geography," and the subordination of geology to geography is already familiar in school teaching. The field covered by geography has been extended in another direction; it has come to include as an essential element those astronomical facts and theories which throw light on variations of temperature, whether these variations are due to the position of the earth relatively to the sun, or to modifications of its own form. The change, therefore, is enormous, since geology stood isolated from every other science concerned with the mineral layers of the earth's crust, cataloguing them by their chemical composition, or, if fossils were found, using them as mere compendious labels. The labels became more dignified as their true relations to existing forms were appreciated; as labels, they must to some extent continue to be used, and too many are satisfied when they have mastered this their lowest function. But while geological enquiries are all biological in their ultimate aim, the language is still that of the earliest investigators. A *system* was a convenient designation of an assemblage of rocks presenting a tolerably definite aspect; a

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formation expressed pretty accurately agreement in physical or chemical characters, and presumably also, therefore, in mode of origin. Age and Period were the terms adopted by those to whom palæontology first revealed the existence of organisms like, yet different from, those now living, whose true affinities have not in all cases been established even yet. Theological and scientific preconceptions dominated, and successive creations and destructions—indicated by ages, periods, epochs, reigns—were the reflex of cataclystic doctrines. At the present day we are violently anti-cataclystic, though the wise caution of a few already suggests that the pendulum has swung too far in the direction of uniform quiescence, and that in our science as in our politics, compromises should be the rule. But every one, Catastrophist or Uniformitarian, uses the terms period and formation, without any attempt to fix the precise meaning of the terms he uses. We are, in truth, to be compared to a party of explorers who, after spending long time on our work, discover that our observations are not comparable, because our instruments were not corrected before starting by reference to any uniform standard. As Evolutionists (to use the term adopted by Professer Huxley in his "Address to the Geological Society of London, 1870"), we use the language of Catastrophists; as men desirous of recording facts, we speak after the fashion of those who squared their facts to their theories.

I need not weary you with a detailed repetition of the geological principles which it is necessary for my argument that you should bear in mind. Let me put them in brief summary.

(1.) Deposits vary at different localities, both in the quantity and quality of their ingredients. The differences testify to change from time to time in the source and direction of the materials, and in the majority of cases a change of materials involves a change in the amount and character of the organisms which the locality supports.

(2.) These variations often depend on the movements of the earth's crust, and such movements vary from time to time in the same locality, both as regards their direction and intensity; stationary intervals of greater or less duration alternating with periods of disturbance.

(3.) The length of these intervals and their recurrence are irregular; nor is there any evidence on which to base calculations, even approximative, of their comparative values.

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(4.) Animals and plants are influenced as regards their numbers and strength by the external conditions under which they are placed. Altered conditions result in their improvement or deterioration, commonly in their migration, and tend to produce permanent structural modifications.

(5.) But their powers of endurance and adaptation are unequal and variable. Changes in the fauna and flora of a region do not therefore furnish any absolute guide to geographical changes. Nor does identity of organisms necessarily tell of identical conditions.

(6.) Each group of plants and animals has its greatest development in space and time not necessarily coincident with that of any other.

(7.) The geographical distribution of plants and animals at the present time had its counterpart in the past. And we have neither geographical nor biological data for estimating the duration and direction of the migrations of which the present is one phase.

Bearing these—which may be fairly claimed as articles in the accepted faith of modern geology—in mind, let us apply them to the definition of a formation.

Mr. Judd, in a note to his paper on the Punfield formation (Quar. Jour. Geo. Soc., Vol. xxviii., p. 225), regrets that *formation* is used by English writers, either for a great group of strata, as the Silurian, or for a division thereof, as the Ludlow, in which latter sense he uses the word in his paper, *system* being applied to the larger groups. The difficulty which he thus indicates is akin to that which would arise were we to attempt the correct employment of the word *vicus*, or village, at the present day. The combination to which the term village is strictly applicable no longer exists in this country, save in a dim, distant, ghost-like shadow. We have transferred the word to any group of inhabited houses, however their association may have been determined. And we do so rightly without scruple, because the birth of the village no longer happens on the old plan. The commune is no longer possible; at least its functions are no longer discharged in the primitive fashion. But in geology the case is different. We are not dealing merely with past events. The same processes are going on, and we must make our terms in accordance with our theories. If the accidental combination of houses rising round a railway junction, a mineral spring, or a convenient bathing locality, took place at the same time as the acquisition by the commune of

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lands to be divided according to the old fashion, it would be manifestly a source of confusion were we to speak of both as villages in the same sense. But as the accidental growth is now the rule, the term is of little consequence. On the other hand, the formation is still going on. What is the best term to describe it?

In a paper of considerable ingenuity Mr. Hull* laid down a Ternary classification of strata, and Principal Dawson has elaborated a Quaternary system.† Now, to give scientific value to either of these speculations, it would be necessary that the three events—dry land, deep sea, dry land—should occupy equal times wherever they recurred; that they should be equal in intensity, and that their foci should coincide. Mr. Hull practically admits that none of these conditions are fulfilled in all cases, since his table omits certain strata, whose absence destroys the integrity of the whole. Mr. Hull, in truth, advocates a catastrophic doctrine as accounting for the separation of each pair of his groups. The elevation which makes the close of a triplet is the disturbance which permits the incoming of a new set of conditions. Obviously Formation means to Mr. Hull the same as period of time, and is determined on fossil evidence. It is a palæontologist's notion, not geographical. The "natural groups" which should contain the three divisions are not defined. If they mean the groups of strata found in *one* locality, and associated in a single continuous series by physical and palæontological concord, then he has not laid down a law of development, but invented a convenient mnemonic for certain localities. If, on the other hand, he means to include in his natural group strata from different localities, but united by common fossils, there is no limit he can rationally assign to his triple colligations. He may either, disregarding the known irregularity in point of time, with which movements of the earth's crust occur, sort out his triplets at discretion; or, bearing in mind, that land and deep sea always exist, abandon the artificial method, and fall back on the natural method indicated by Professor Huxley—that is to say, confess the impossibility of trustworthy classification by putting the land surface in a parallel column to the marine; the two columns containing each an unknown quantity; on the one hand the length of time spent in the working out of physical phenomena;

* Quarterly Journal of Science. † Acadian Geology.

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on the other the length of time required for the completion of biological changes.

The Quaternary classification of Principal Dawson is more complicated than Mr. Hull's.

PALÆOZOIC CYCLES. E. AMERICA.

Shallow subsiding marine areas filling up with sediment, ..	Hudson R. Group.	L. Helderberg.	Chemung.		U. Coal Formation.
Elevation followed by slow subsidence, land surfaces, &c.,..	Utica Shales.	Salina.		Hamilton.	Coal Measures.
Marine conditions, Limestone,	Trenton. Black R. Chazy.	Niagara. Clinton.		Corniferous.	L. Carb. Limestone.
Subsidence, disturbance, deposition of coarse sediments,	Potsdam. Calciferous Sandstone.	Oneida. Medina.		Oriskany.	L. Coal Measures, and Conglom.

Admitting for the moment that this table represents equal values for America, let us apply it to Europe. Take the Carboniferous. The Carboniferous Limestone series and the Coal Measures fix two points in the table. The first stage of "subsidence, disturbances, deposition of coarse sediments," is represented by the Upper Old Red Sandstone, with its volcanic rocks and conglomerates, and the Calciferous series or Limestone, shales, coals, ironstones; an enormous thickness of strata representing two diverse physical conditions—that of the Old Red and the oscillating marine condition of the early Carboniferous. But in England this lower group is of different proportions and contents, the two countries presenting little agreement at this stage. The continuous mass of the English Limestone again testifies to a very different set of things from the coal-bearing strata of Scotland. The Coal Measures of England are purely terrestrial; those of Wales, partly marine. The comparison of the Carboniferous Limestone of Limerick with that of England and Scotland is interesting in this point of view. The absence of *Productus giganteus, Lingula, Crania, Anomia,* is remarkable. Of 138 species, 58, or 42 per cent., are not met with in Scottish limestones, the latter possessing a much larger ratio of shallow-water forms. In the north of Ireland, Mr. Hull has pointed out that from Fermanagh towards the north-east the Scottish type of Carboniferous rocks is gradually assumed. The specific agreement is greater here; of 33 species, 15, or 46 per cent., are common. In both areas the Cephalopoda are fewer than in the south, the estuarine, or even fresh-water Ganoids, being more abundant. Finally, the upper Red Sandstone, with the

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thin Limestone, cannot be regarded as the equivalent in any sense of the groups of strata below the coal. The case is all the more complicated if we find that the Russian Devonian rocks include fossils which belong to the British Devonian seas on the one hand, and the British Old Red Sandstone rivers and estuaries on the other. This latter fact brings into prominence the difficulty of cyclical arrangement, for there is no proved superposition in Britain of Devonian to Old Red Sandstone; and it is equally prejudicial to the views of Hull and Dawson whether these groups of strata are regarded as of the same or of different age. In either case we have a sea to interpose between two land periods; and unless we go to Germany for the upper and lower subsidence seas, there are only probabilities to fall back on as regards the Old Red Sandstone. Nor is the complication yet at an end. Professor Ramsay has shown that some of the groups of strata slumped under the designation Silurian are not in reality physically continuous, but both stratigraphically and palæontologically are separated from each other. If, therefore, the Llandeilo and Caradoc beds are separated by a break in the succession of life, and by an unconformity from the Lower Llandovery; and if the Lower Llandovery is similarly cut off from the Upper Llandovery, we have an unclassifiable group in the Caradocs which is either equivalent to all the rest of the Silurians, containing sedimentary and calcareous strata; or, if it is regarded as one of the four stages, the Bala and Hirnant limestones must have an importance attached to them altogether out of proportion to their actual dimensions.

If we take the Cretaceous series, we find that the land surfaces of the Wealden and Purbecks are placed in the vertical table as of equal value with the marine beds; and as a record of British strata there is no exception to be taken to it. The Geological Survey has departed from the rule that all strata not found in Britain are to be stuck into the British series—into those gaps which palæontological refinement is sorely taxed sometimes to demonstrate statistically. The index map contains parallel columns for the Devonian and Old Red Sandstone, the Carboniferous, Permian, and Cretaceous series, the difference of local development forbidding their generalisation. In France the Cretaceous series loses in thickness towards the south, and the highest beds are, in truth, a Wealden deposit. Coquand objects to the development

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of one region being taken as the standard for another, and the remarkable absence in the south of France of the cephalopods which figure so largely in the deep-sea deposits to the north, illustrates very well the differences of distribution of animals, which render strict comparisons difficult. Now, since there must have been dry land somewhere, we seem to have the shore of the Cretaceous sea during depression along the line of the English Greensand; and the shore during the later part of the Cretaceous sea, if not during re-elevation, in the south of France. But it may be said that all this is petty criticism—that we must take broad views: we must look over large areas, and not confine ourselves to limited localities. In other words, we are asked to generalise great areas, and to average geographical changes. There would be no possible objection to this if the changes were parallel all over these great areas, and if strict contemporaneity were demonstrable. But this habit of taking large views is premature; we do not know the details sufficiently, and it is difficult, when one hears of these broad views, to realise the fact that those who advocate them strongly disavow the old catastrophic doctrines. Yet generalisations of the kind I object to are practically an attempt to establish the same phenomena as occupying the same time—to establish what Herbert Spencer denominated the onion-coat theory of geology. Take the broad view, and what do we arrive at? Only this, that elevation and depression are successive to each other, a doctrine which needed no elaborate scheme to establish. A greater service would be rendered by any one who, starting with the axiom that great depths and great heights co-exist with each other, and upward with downward movement, should try to show what were the corresponding heights and depths.

The Scottish Coal Measures were probably the equivalents in point of time of large part of the English Coal measure series, including a considerable portion of the Carboniferous Limestone. The Scottish Carboniferous Limestone was, in fact, partly a shore accumulation to the deep-sea limestone, while the barrier running east and west across England gave another land surface. While, therefore, in Scotland, or at any locality in England, the series is represented by a vertical column—

Land,
Sea,
Land,

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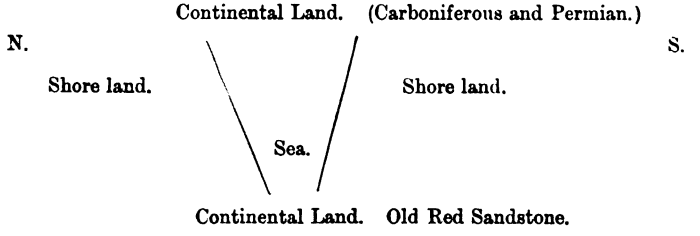
the history of the Carboniferous development in Britain would be represented thus:—



The Devonian history would perhaps be represented thus:—

British Carboniferous Continent. Russian Carboniferous Continent.

Devonian Sea.

Dr. Dawson makes out a stronger case against his own arrangement when he dwells on the greater affinity of the Devonian to the Mesozoic than to the Carboniferous flora; for he thus demonstrates the broad view of a continuity of continental land during all that great interval, and correspondingly localises the vertical succession he tabulates.

If, then, there is not much to be made of cyclical arrangements, will continous vertical tabulation help us? Perhaps these generalised tables of strata have done more to perpetuate erroneous notions than any more explicit statements. The British strata, all put in a column, do not represent the truth for any locality in Britain any more than they form a standard for the world. The simultaneous distinction and re-creation of animals and plants would, as a creed, require the vertical tabulation. But the more the geographical conception of a formation is adopted, the more numerous will become the parallel columns of our stratigraphical tables. The following sections in Britain will illustrate the facts lost sight of in the ordinary method of statement:—

Ross-shire.	Dumbarton.	Dumfries.	Warwick.	Anglesea.	S. Wales.	I. of Wight.
Oolite.	C. Meas.		Trias.	Permian.	C. Meas.	Eocene.
Old R. S.	M. Grit.		L. Permian.	C. Meas.	M. Grit.	Cretaceous.
L. Silur.	C. Lime.	C. Lime.	C. Meas.	M. Grit.	C. Lime.	Wealden.
Cambrian.	L. Carb.	Permian.	C. Lime.	M. Grit.	Old. R. S.	
Laurentian.	U. Old R. S.	L. Silurian.		Old R. S.	L. Silurian.	
	L. Silurian.			Cambrian.		

It may be perfectly true that if we bored down from the Isle of Wight we would find some, or all, the members of the

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Palæozoic series. There is no evidence one way or the other, as we do not yet know the depth at which metamorphism destroys the characters of sedimentary rock. But it is absolutely certain that such a bore would not pass through all the strata enumerated in the tables. The Harwich bore passed through

Drift,	25 feet.
Tertiary strata,	51·5 ,,
Chalk,	888 ,,
Greensand and Gault,	61 ,,
Black slaty rock (Palæozoic),	44.5 ,,
	1070 feet.

What may have been the thickness of this Palæozoic rock mass, it is idle to speculate on; but if the total thickness of above thirteen miles be attained by the sedimentary strata, their proportions must be different from those quoted by Darwin from Professor Ramsay. As the table given in the "Origin of Species" has been made somewhat unfairly to misrepresent its author's meaning, it is here subjoined.

"Professor Ramsay," says Mr. Darwin, "has given me the maximum thickness—in most cases from actual measurement, in a few cases from estimate—of each formation in different parts of Great Britain, and this is the result:—

Palæozoic strata (not including igneous rocks),	57,154 feet.
Secondary strata,	13,190 ,,
Tertiary strata,	2,240 ,,

making altogether 72,584 feet; that is very nearly thirteen and three-quarters British miles. Some of the formations which are represented in England by their beds, are thousands of feet in thickness on the Continent. Moreover, between each successive formation we have, in the opinion of most geologists, enormously long blank periods. So that the lofty pile of sedimentary rocks in Britain gives but an inadequate idea of the time which has elapsed during their accumulation; yet what time this must have consumed!"

No one will dispute the measurements, but Professor Ramsay is not answerable for the conclusion that the British sedimentary strata represent thirteen and three-quarters miles in thickness. Such a notion is, in fact, at variance with his own teaching. The generalisation is one which loses sight of the geographical accidents

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on which the deposit, the denudation, and the preservation of strata depend. My reason for drawing attention to this point is that Mr Darwin's remarks, which I cannot but think are based on a misunderstanding of the case, have been transferred in quotation to Professor Ramsay, who, in spite of his very clear statements in his memoir in the "Pretriassic Red Rocks of England" (Quar. Jour. Geol. Soc., vol. xxvii., p. 241), is represented as ignoring the geographical variations of sedimentary deposits.

What, then, is the definition of a Formation? What is the view which will enable us to escape the vagueness, if not the errors, which, as seems to me, are perpetuated in current language? It would be safer for me to describe a formation than to attempt at present the precise definition. A formation, then, is an accumulation of sedimentary deposits (with or without contemporaneous igneous rocks), in which are entombed the remains of plants or animals, whether marine or washed down from adjacent land; but in either case giving account of the life of a particular district. In other words, a formation represents a larger or smaller biological province. The Reptilian and Amphibian fossil remains indicate that the Arctogæal province was marked out in Pretriassic times; in other words, that so far as the land population went, the north of Europe, Asia, America, and the South of Africa belonged to one great province. But it would be unwarrantable to conclude that therefore the adjacent marine areas were of corresponding dimensions. This want of parallelism between the terrestrial and the marine organisms has led to much confusion as to the geographical relations of Africa, among other questions.

There is a general belief that in former times there was a greater uniformity of life on the surface of the globe than there now is. Mr. Salter says (Quar. Jour. Geo. Soc., 1865), that zoological provinces recognisable in Silurian areas diminish in distinctness, thereafter disappearing in Carboniferous areas. Contrary assertions have been made to the effect that the amount of representative forms, not identical, was greater in the past than in the present. These conflicting opinions are explicable by reference to the fossil groups on which the generalisation is based. Those who advocate a greater amount of representation in the past rest their case on Mesozoic fossils. The great antiquity of the Southern Continents here comes into play. The molluscs (for they were chiefly regarded) have long been domiciled in the Southern Seas,

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and their modification has been effected through long lapse of ages. The early Mesozoic molluscs of Europe have a greater resemblance to the South African molluscs, because they are nearer in time to their common origin (for the writers to whom I refer accept the common ancestry). The terrestrial condition of South Africa dates from about the Carboniferous, the Triassic strata of that region yielding a well-marked amphibian fauna. But the changes in that region thereafter were few. There was probably a greater dispersion of fossils at the close of the European Carboniferous than there was in Africa, and the changes in the former have since been vastly greater than in the latter area.

The singular circumstance connected with the advocates of these antagonistic views is, that the one set assert and the other deny that identity of fossils is proof of contemporaneity. To the former it is natural to regard the wide range of Silurian forms as proof of former greater uniformity; though, of course, the criticism is obvious, that more stress is laid on individual resemblances than on the character of groups. It is illogical for the latter to urge representation as a marked feature in Mesozoic times, because, in the particular case I have chosen, migration must have taken place to a considerable extent before the representation could have occurred. There is here, as in many other cases, a residuum of unconscious belief in the old notion that formations in former times covered large tracts of the earth's surface.

It must be remarked, in justice to Mr. Salter, that in his memoir on the Himalayan fossils he does not attempt to intercalate the species he recognises in the British standard. Had he done so, as has been done in obedience to the statistical method in the case of the Tertiaries, the bulk of the Silurian strata would have attained enormous dimensions.

One phrase of frequent recurrence is evidently residual of Catastrophic doctrines. I mean the "base of a formation," which is sometimes said to be wanting. The conception underlying such a phrase is that the only "complete" formation is one which begins and ends in conformity with the inferior and superior strata. To the same category belongs the phrase "incomplete;" it is usually—in this country, of course—applied to departures from our insular standard of stratigraphy, and, in so far, is on a par with the zoological phrase "imperfectly developed." Both

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suggest disregard of conditions. The zoologist loses sight of physiological fitness—the geologist of movements of the earth, with or without climatal changes. If formations were complete according to the standard I have mentioned, the onion-coat theory is the only one which would justify the phrase. The absence of the base means only unconformity. We have the lowest beds for that locality—not, perhaps, all that were ever laid down, but the first of those the conditions of whose deposits were comparatively permanent.

The anxiety with which the strict co-ordination of strata is attempted testifies to an implied belief in the possibility of strict parallelism. But the cases of admixture of forms belonging to various horizons yield (when extreme ones are selected) insuperable difficulties. Thus Dale Owen describes in the Cedar Valley a group of rocks intermediate between Silurian and Carboniferous strata. There are 18 species in the shell beds and the coral layers which lie above and below them. Of these 18 there are nine common to this country, ranging—one from Bala to Middle Devonian, one Caradoc to Wenlock, one Upper Silurian to Middle Devonian, one Bala, one Upper Silurian, two Middle Devonian, one Lower Carboniferous. The equivalence here is between a section of 70 feet in the Cedar Valley and nearly 10,000 feet in this country—a mass of rock which, moreover, represents, as tested by unconformities, several very distinct sets of physical conditions. Other cases might be cited. The Devonian of France and of Spain contain Silurian, Devonian, and Carboniferous species found in Europe and America, and some even in Asia. Dr. Duncan finds evidence of mixture of stages in the Corals of Scinde; and Hall notes in America the gradual passage of the Devonian into the Carboniferous series, a passage which unites characters distinct in Britain. It is needless to multiply instances: these are those which come first to memory. We admit, though we sometimes require to be reminded of the fact, that no two sets of strata, at a moderate distance apart, agree as to their fossils, whether the difference is due to mixture of remains from strata elsewhere distinct, or the presence of species peculiar to one in addition to those common to both localities.

I might give many and interesting details regarding the manner in which, along any coast line, the faunas gradually become distinct—the statistical method yielding results as regards

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horizontal replacement of faunas more striking than the successive faunas of the Tertiaries. But you are already familiar with these facts, and I would rather consider the difficulties which lie in the way of applying practically the geographical definition of a formation. Dawson, in his Acadian Geology, speaks of a passage in the earth's history, the Permian, as unrepresented in America, and, contesting the Homotaxial doctrines of Huxley, urges the uniformity of Carboniferous type over great areas, notably in America. This reasoning in a circle is the more curious, that in speaking of the Lower Carboniferous strata he recognises a Permian character in the limestone fossils, albeit there are present at the same time fossils which do not elsewhere ascend higher than the Lower Carboniferous strata. It is obvious, that so long as there exists a fundamental difference of opinion as to the origin of species—so long as some ascribe to migration and long time results which others deny to be possible save by creative effort—there is no common ground on which to construct generalisations applicable to more than limited portions of the earth's surface. There is not, moreover, at present, sufficiently detailed knowledge of many localities to permit of close comparison: but the need is all the greater of so restricting our terminology that in the future there will be the least possible need of altering or replacing terms sanctioned by long use. If, therefore, it were understood that by *formation* was meant merely a deposit found in one locality, and presenting a certain sum of animal and vegetable life, and that it was not necessarily the equivalent, either in chronology or in duration, of any other deposit, however closely similar might be its fossil contents, the advocates of antagonistic doctrines as to the origin of species might meet on common ground. Such consent is not likely to be secured, for the doctrines to which I have referred are commonly held with a tenacity unfavourable to compromise. But it would be an enormous advantage if writers would define at starting the sense in which they employ "formation" and other similar terms.

I had intended to investigate the terms *unconformity* and *overlap*, *grit*, and one or two others, but what I have said as to the word "formation" may be perhaps the means of suggesting to yourselves the necessity of carefully enquiring what meaning you attach to your words, and of watching, lest you confuse yourselves

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by varying, however slightly, the notions you connect with particular terms. This, not the reform of geological nomenclature, was my purpose. I hoped to suggest an instructive lesson for yourselves, not to propound rules for general acceptance. And in handing over, as I now do, my office to my colleague, Sir W. Thomson, I know that in place of the hints which alone I can offer you, you will receive from him positive practical guidance in the investigation of problems which it is foreign to my province even to touch upon.

IX.—*Notes on a* Section of Strata *containing Beds of* Impure Coal *and* Plant-remains, *showing* Structure, *at* Glenarbuck, *near Bowling.* By John Young, V.P.

(Read 14th Dec., 1871.)

Since the period when the late Mr. Currie, of Bowling, communicated to this Society a short notice on the occurrence of one or two beds of impure coal, interstratified amongst the traps of the Kilpatrick hills, in Auchentorlie Glen, near Bowling, other evidence of interbedded strata, containing remains of plants and fishes of carboniferous age, has been obtained from the same district.* Another instance still of the occurrence of coal-beds and shales with plant-remains, in these hills, has recently come under my notice, and is to be seen in the gap of the hill above Glenarbuck House, a mile or so to the eastward of the former locality. As the beds are thus shown to have a considerable extension amongst the traps of the Kilpatrick hills, and as they clearly establish the carboniferous age of the various outflows of igneous rock-matter of which these hills are principally built up, I have thought it right that this other discovery should be recorded in the Transactions of the Society.

Before noticing, however, the coal-beds and plant-remains referred to, and the conditions under which they occur, I will point out briefly the relations of the various strata that underlie the traps of the Kilpatrick hills to the north-west, in order that their age may be more clearly placed before you. The lowest traps of this range

* See Trans. of this Society, Vol. II., p. 149; also Vol. IV., p. 77.

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evidently erupt through, and at various points overlie, strata of the Ballagan series and the Old Red Sandstone. But probably those massive, thick-bedded white and red sandstones, which immediately underlie the Ballagan series, may yet be determined to be of lower carboniferous age, and found to rest conformably on a lower set of red sandstones of Devonian age that flank the Silurian schists of the Grampians and Dumbartonshire hills to the north-west.

The lithological character of the Ballagan series in this district does not differ much from that observed in the Campsie and Strathblane hills, described in a former paper.* The group to the west of the Kilpatrick hills consists, in descending order, of—1st, an upper series of yellowish-white sandstones that immediately underlie the trap; 2d, a group of thin bedded grey limestones and dark-grey marly shales, apparently devoid of fossils; and 3d, a lower series of thin bedded greyish-white sandstones, in which I have found some obscure plant-remains and scales of ganoid fishes, these being the only organisms yet detected in the group in that district. The best sections of these strata are to be seen in Auchenreach and Dumbuck glens, a short distance from the town of Dumbarton, and north-east of the confluence of the Clyde and Leven, where they crop out on the hill sides beyond the termination of the trap.

The lower sandstones of the Ballagan series rest upon, and are apparently conformably to, a thick group of white and red sandstones which occurs in the valley of the Leven and along the shores of the Clyde, and which are extensively wrought for building purposes in the quarries near the town of Dumbarton and at other points in the Leven valley. So far as I am aware, these sandstones have yielded no fossils, and the only traces of anything organic yet observed in these rocks are numerous small spots and circular blotches of black carbonaceous matter, already described in the Transactions of this Society.†

The whole of the strata under review, to the west of the traps of the Kilpatrick hills, have a general rise to the north-west, or towards the Silurian schists of the Dumbartonshire hills, which extend in that direction. The bedded traps of the hills to the east also partake of the same general rise. From this it is evident that the latest movements which have elevated these Silurian rocks are

* Vol. II., pp. 33 and 207. † Trans., Vol. I., Part 1.

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of more recent date than the eruption of the various sheets of trap that form the upper portion of these hills.

None of the bedded traps of the Kilpatrick range extend into the district west of the Leven valley. In the northern portion of the hills, these igneous rocks are seen to rest on the white and red sandstone group before mentioned. Nearer the confluence of the Leven and Clyde they rest on the members of the Ballagan series. From the distinctness, therefore, with which the various outcrops of strata lying under the trap can be made out, the more recent age of the coal-beds and other strata containing plant and fish-remains that lie in their midst is satisfactorily established.

The section on the hill side at Glenarbuck, from which we have obtained the other evidence of coal-beds and strata with plant-remains, is one of considerable interest, from the satisfactory manner in which the woody structure of many of the plants have been preserved. Being found in a calcified condition, like those from the Arran ash-beds, the plants are wonderfully well preserved by the infiltration of carbonate of lime into the wood cells. The beds lie on the western slope of the hill, under a high precipice of trap which is opposite a lower and more depressed cliff facing the east—probably an extension of the same bed of igneous rock let down by a fault. The gap between these two cliffs—several hundred feet in width—forms a conspicuous feature of the landscape of this portion of the hill, when viewed from the low ground or the river Clyde. In the hollow of the gap there lie huge masses of trap fallen from these cliffs, and they are also to be found scattered along the banks of Glenarbuck burn for a considerable distance downward. The annexed woodcut will show more clearly the relation of the beds :—

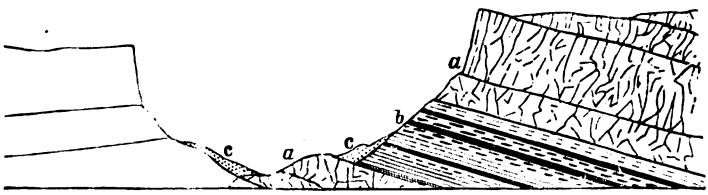

Diagram section of the strata in the gap at Glenarbuck. a a, Bedded traps; b, Strata with plant remains and seams of impure coal; c c, Debris of trap, &c.

The above section, in which the seams of impure coal and plant-beds lie, may be from 20 to 30 feet in thickness. Probably it is

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more, for its base is not well seen on account of the *debris* that covers it. The lower portion of the hill under these strata consists of massive bedded traps of varying mineral character; but amongst them I have observed no other coal strata, although in Auchentorlie Glen, to the westward, one of the coal-beds noticed by Mr. Currie is seen at this low level, so that it is possible the outcrop here is concealed.

The upper bed of peaty coal in Auchentorlie Glen is probably lying on the same horizon in the traps as that seen at Glenarbuck, except that, in the latter locality, the coal-seams appear to be more fully developed and in better preservation, although no traces of fish-remains have yet been discovered. It is more than probable that the beds of foul coal in the Glenarbuck section have been previously observed by persons wandering along these hills, but no notice, so far as I am aware, has ever been published. They only became known to me last summer while in Glenarbuck on an excursion with Dr. Young, Dr. Dickson, and the students attending the natural history and botanical classes at the University. While there I noticed, in the face of a small crumbling escarpment, under the high cliff of trap already mentioned, what appeared to be stratified deposits. On climbing up to the section I found that the beds consist of friable, yellowish-grey volcanic mudstones, or shales, with seams of foul coal, in which the woody structure of the plants is very distinctly preserved in a carbonised condition, as will be seen from the specimens submitted to the meeting. The highest layers of coal in the section are from 2 to 3 feet in thickness, and although of a very impure quality, and considerably altered by the heat of the overlying trap, yet they give off some flame in the burning. The beds dip to the south-east, and are overlaid by porphyrite, dolerite, and other traps, which are in different places amygdaloidal; and from them, in former years, good specimens of several varieties of zeolites were obtained, both at this place and at the Longcraigs, a little to the north-west; but these minerals are now very rarely met with on this tract of the hill.*

* Professor Dickson, during a second visit to Glenarbuck with his students in July, 1872, has discovered that there occur, in the shales under the coal seams, uncrushed roots of *Stigmaria*, in which the woody structure is wonderfully preserved in a calcified state, and all the various internal parts of the plant clearly defined. In some instances, indeed, their long, slender, hollow rootlets have had their structure preserved, a circumstance seldom observed in these plants from other localities.

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On another visit to this interesting section, along with Dr. Dickson, we dug up a considerable number of other specimens of plants showing structure. Apparently they are all *Stigmariæ* and portions of *Sigillariæ*, though whether of the same species cannot be satisfactorily determined until microscopic sections be made. We could find no trace of erect stems of *Sigillariæ* in this deposit, however, and concluded that such as had grown on the spot had decayed ere they were covered up, and that it is the partly macerated vegetable matter of these *Sigillariæ* that has gone to form the beds of impure coal that overlie the Stigmarian beds.

The conditions under which these plants and coal beds occur are very similar to those which have been observed in the Arran ash-beds,* except that the beds at Glenarbuck are softer and more easily dug into. No other plant-remains were discovered but such as are referable to *Stigmariæ* and *Sigillariæ;* but as the Glenarbuck beds have been but little explored, future researches may reveal other genera.

One of the points of interest connected with these Stigmarian stems is the large size of the inner wood cylinders—the best preserved portion of the plant in this locality—which in some specimens measure fully two inches in diameter. These, in the cross-sections, show clearly the arrangement of the radiating wedge-shaped bundles of woody fibre which proceed from the central axis, and in the vertical sections the longitudinal striæ of the same. Very little of the loose vascular structure of the central axis or outside portions of these plants has been preserved except what is seen in the extension of the rootlets.

If I were to express an opinion as to the age of the coal-beds in the trap of the western extremity of the Kilpatrick range, I would be inclined to place them in the Calciferous Sandstone series, which underlies the lower carboniferous limestone of the West of Scotland. They are thus, in all probability, of the same age as the Arran plant-remains, found embedded amongst traps and ashes on the north-eastern shore of that island. These coal-beds and shales, with plant and fish-remains, reveal the interesting fact that, during the time when these traps and trappean ashes were being ejected by the volcanoes of the lower carboniferous period, long intervals occurred, in which forests of *Sigillariæ*

* Vol. II., p. 97.

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and other plants flourished over these tracts and accumulated vegetable matter sufficient to form thin seams of coal. These were subsequently overlaid in some cases by lake deposits, in which the remains of fishes were embedded; and these, in their turn, by other outbursts of igneous rock-matter and ashes. This portion of the Kilpatrick range accordingly reveals a geological structure similar to that of a more recent period shown in the bedded traps of Mull, enclosing coal and plant-remains of Middle Tertiary age.

NOTE.—Since the above was written, Mr. D. BELL, Secretary, has brought under the notice of the Society some plant-remains found embedded in the traps of the Lochwinnoch district, to the south-west of the locality above described. These were discovered in a bed of volcanic ash or mud, which occurs in the trap range to the north of Lochwinnoch; and though externally a good deal worn, and the structure not very well preserved, appear to belong to the genus *Lepidodendron*. The matrix in which they are found is quite similar in colour and composition to some of the interbedded ash or mud beds that lie amongst the traps of the Campsie hills.

X.—*On the* POST-TERTIARY FOSSILIFEROUS BEDS OF SCOTLAND. By DAVID ROBERTSON, F.G.S., and Rev. H. W. CROSSKEY, F.G.S.

(Continued from page 45.)

XIII.—KILCHATTAN TILE-WORK, BUTE.

IN this series of papers on the Post-Tertiary Deposits, it has been our desire all along to confine our attention to their fossil remains, and to some facts connected with their inorganic contents, avoiding, as far as possible, the introduction of theoretical matter. This will account for our passing over unnoticed many topics of interest with regard to glacial phenomena.

The section now under review has been described by several writers, particularly by Mr. Jamieson in his valuable paper "On the Last Geological Changes in Scotland;"* and by Professor Geikie, in his well-known memoir on the "Phenomena of the Glacial Drift of Scotland," published in the Transactions of this Society.†

* Quart. Jour. Geol. Soc., Vol. XXI.

† Vol. I., Part 2.—Mr J. Coutts has also, with much industry, made a large collection of shells from Kilchattan, which were exhibited at a meeting of the Natural History Society of Glasgow.

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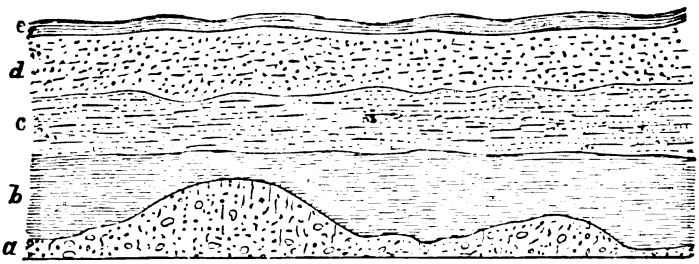
The deposit lies at the north-west side of Kilchattan Bay, beyond tide-mark, and dips seaward. Taking the beds in descending order, we find, as represented in the annexed cut:—

I.—Peaty mould: about 1 foot.
II.—Gravel: 3 to 5 feet.
III.—Muddy sand: 4 to 6 feet.
IV.—Grey laminated clay: 6 to 7 feet.
V.—Reddish boulder clay: depth unknown.



Section showing position of shell-bearing clay at Kilchattan Tile-Work, Bute.
a, Boulder clay. b, Laminated clay. c, Sandy mud, with shells, &c. d, Gravelly mould. e, Peaty mould.

Passing over I. and II., it is in the stratum of muddy sand (III.) that the shells occur, and it is to be observed that they are more abundant therein towards the bottom than near the top. The proportion of sand in this layer is too great for tile-making, and it is therefore laid aside.

The prevailing shells of this deposit are *Tellina calcarea*, *Axinus flexuosus*, *Scrobicularia prismatica*, *Cyprina Islandica*, *Mya truncata*, and *Utriculus obtusus*. Most of these reach a size rather above the average of those met with in the Clyde beds generally. At the same time we remarked that, contrary to what is usually found, all these are abundant from the fry up to the adult forms, shewing, as regards this deposit, that the conditions for all stages of growth of these various species had been exceedingly favourable.

The majority of the *Myas* were found to have both valves preserved, together with remains of their siphons in position within the shells. This sandy material seems to be favourable for the preservation of this portion of the animal tissue. Siphons have been met with in the soft clay of other localities, but rarely.

Another point worthy of notice is that a number of the valves of *Mya truncata* have thick patches of the muddy sand in which they are imbedded indurated on their inner surface so firmly as not to be removed even by boiling water. Similar hard clays are

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occasionally found in shells taken from other post-tertiary deposits. These patches generally do not extend over the whole interior of the shell, but are confined to a particular spot or region. Sometimes we have met with hard nodules of clay which, when broken, disclose a cluster of small shells embedded within, much like the well-known clay nodules enclosing shells or fish remains, in other formations.

These indurated patches of sand and clay within the shells, and those enclosing shells, as well as the clay nodules found in many of our brick clays, that have no apparent organic nucleus, have all, so far as we have examined, a strong calcareous base, while the clays in which they are embedded have none.

In this deposit many of the plates of *Echinus Dröbachiensis* are much corroded, as we find them in some othor localities. We take this opportunity to remove a doubt we had regarding the identity of these eroded plates as referred to in a former paper, where a plate is given of the various forms.* From the singular way in which the plates were corroded, leaving a regular pattern, we were led to think they might be plates of an undescribed species—an opinion shared by some carcinologists of the highest authority. Since that time, however, so many of these plates have come under our notice, that we have been able to trace the erosion from its first effect to the full formation of the pattern referred to, leaving no doubt that they are all the plates of one species, the *Echinus Dröbachiensis.*

The grey-coloured laminated clay (IV.) is formed into layers by thin bands of red sand, which are thicker and more distinct as they approach the bottom. Here the clay between them is again divided into exceedingly thin layers. No shells have been met with in this clay, and it has hitherto been considered azoic; but lately we examined a portion of it in which *Ostracoda, Foraminifera,* and one much-decayed fragment of an oval plate of an *Echinus* were obtained. Of Ostracoda there were three valves of one species, *Cytherura Sarsii.* Of Foraminifera, twelve specimens of *Nonionina depressula,* and three of *Polystomella striato-punctata* were obtained.

The piece of clay from which these were taken was somewhat less than 3 lbs. in weight, showing that it was not so destitute of life as had hitherto been supposed.

* Transactions of this Society, Vol. III., p. 1.

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It may be mentioned that a much larger portion from the same stratum had previously been examined by us, without finding a vestige of animal remains. This indicates how unsafe it may often be to pronounce such deposits unfossiliferous from one trial, inasmuch as the organisms may not be equally distributed through all parts of the same stratum. As this is a point of some interest, we shall endeavour to ascertain, when opportunity occurs, whether these organic remains are to be met with at any particular depth of the stratum in which they are found, or whether they are located promiscuously at different depths.

It is this clay only that is used for tile-making. When dry, it is of a lightish drab colour, and consists of

99¼ per cent. fine mud,
¼ ,, fine sand,

with occasionally small pebbles, less than the size of a common pea.

The boulder clay (V.) is, as has been stated, of a reddish colour, very uneven, at some places rising up in knolls so far through the grey clay as nearly to reach the muddy sand layer above. This clay, when dry, consists of

51 per cent. fine mud.
28 ,, fine and coarse sand.
21 ,, gravel.

The shell-bearing clay consists of

32 per cent. fine mud.
68 ,, fine sand.

LIST OF ANIMAL REMAINS FROM KILCHATTAN TILE-WORK.

PISCES.

A few small vertebræ.	Not determined.

CONCHIFERA.

Anomia ephippium, Linn.	Moderately rare.
Pecten Islandicus, Müll.	Rare.
Mytilus modiolus, Linn.	Moderately rare ; mostly fry.
Nucula tenuis, Mont.	Rare.
Leda pernula, var.	
—— *mucilenta*, Steenst.	Common.
—— *pygmæa*, var.	
—— *lenticula*, Möll.	
Montacuta ferruginosa, Mont.	This species is copied from Mr. Jamieson's list of the shells of Kilchattan.
Axinus flexuosus.	
——— var. *Gouldii.*	Common and well grown ; many with the valves together.

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Cardium edule, Linn.	Rare; half grown.
——— *echinatum*, Linn.	Rare; fry.
Cyprina Islandica, Linn.	Common; all sizes from the fry up to very large.
Astarte compressa, Mont.	Common.
Tellina calcarea, Chemn.	Common; all stages of growth, but few marking beyond a medium size.
Mactra subtruncata, Da Costa.	Rare.
Scrobicularia prismatica, Mont.	Moderately common. This species is rather rare in the west of Scotland as a post-tertiary shell.
Mya truncata, Linn.	Common; all sizes.
Saxicava rugosa, Linn.	Rare.
Pholas crispata, Linn.	A fragment.

GASTEROPODA.

Chiton plate.	Too obscurely marked for determination
Tectura virginea, Müll.	Rare.
Trochus cinerarius, Linn.	Small, and much eroded.
——— *tumidus*, Mont.	Moderately common.
Lacuna divaricata, Fabr.	Moderately common; small.
Littorina littorea, Linn.	Moderately rare.
——— *obtusata*, Linn.	Moderately rare.
——— *rudis*, Maton.	Rare.
Rissoa parva, Adams.	
——— var. *interrupta*.	Moderately common.
——— *striata*, Adams.	Moderately rare.
Skenea planorbis, Fabr.	Moderately common.
Homalogyra atomus, Phil.	Moderately common.
Odostomia unidentata, Mont.	Rare.
Natica Grœnlandica, Beck.	Moderately common.
——— *affinis*, Gmel.	Moderately common.
Velutina lævigata.	One fry; Mr Coutts.
Aporrhais pes-pelicani, Linn.	Rare.
Purpura lapillus, Linn.	Rare.
Buccinum undatum, Linn.	Moderately rare.
Trophon clathratus, F. and H.	Rare.
——— *truncatus*, Ström.	Moderately rare.
Fusus antiquus, Linn.	Rare.
Pleurotoma violacea, Migh. and Ad.	Rare.
——— *turricula*, Mont.	Moderately rare.
——— *Trevelyana*, Turt.	Rare.
——— *pyramidalis*, Ström.	Rare.
Utriculus obtusus, Mont.	Common.
——— *hyalinus*, Turt.	Rare.

POLYZOA.

Crisia eburnea, Linn.	Rare; one small branch.

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CRUSTACEA.

Plates and claw.	Too fragmentary to determine.

OSTRACODA.

Twenty-two Species.

CIRRIPEDIA.

Balanus porcatus, Da Costa.	Common and large.
——— *crenatus*, Brug.	Moderately common; rather small.
Verruca Strömia, Müll.	Rare.

ANNELIDA.

Serpula vermicularis, Ellis.

ECHINODERMATA.

Ophiura albida, Forbes.	Moderately common.
Echinus sphæra.	Plates and spines.
——— *Dröbachiensis*, Müll.	Plates and spines; many of the plates much eroded; similar to those met with in a post-tertiary deposit at Cumbrae, Buteshire, and other places. (*See* remarks at p. 130.)
Amphidotus, sp.	Spines and plates.

FORAMINIFERA.

Biloculina ringens, Lamk.	Common.
——— *depressa*, D'Orb.	Rare.
Quinqueloculina seminulum, Linn.	Moderately common.
——— ——— *subrotunda*, Mont.	Rare.
Lituola scorpiurus, Monfort.	Rare.
Lagena lævis, Mont.	Rare; deformed var.
——— *striata*, Mont.	Moderately common.
——— ——— var. *apicula.*	Moderately rare.
——— *distoma*, P. & J.	Common.
——— *globosa*, Mont.	Moderately common.
——— *marginata*, Mont.	Moderately rare.
Dentalina communis, D'Orb.	Moderately rare; very weak.
Cristallaria rotulata, Lamk.	Moderately common.
Polymorphina lactea, W. & J.	Moderately common.
——— ——— var. *communis.*	Rare.
Verneuilina polystropha, Reuss.	Moderately common.
Bulimina pupoides, D'Orb.	Rare.
Cassidulina lævigata, D'Orb.	Rare.
Truncatulina lobatula, Walker.	Moderately rare.
Rotalia Beccarii, Linn.	Moderately rare; very weak.
Polystomella striato-punctata, F. & M.	Moderately rare.
Nonionina turgida, Will.	Moderately common.
——— *depressula*, W. & J.	Moderately common.

SPONGE.

Cliona celata, Grant.	Moderately common.

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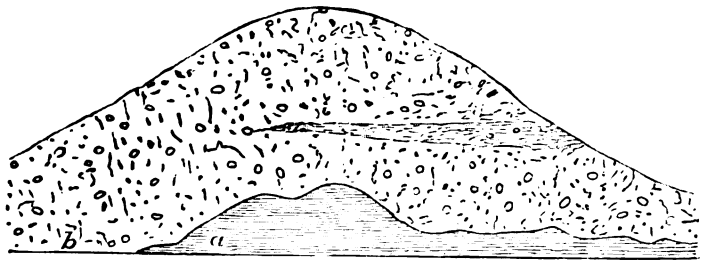
XIV.—TANGY GLEN, NEAR CAMPBELTOWN.

The section now to be described* occurs in what is called *Tangy Glen*, about six miles from Campbeltown, on the road to Tarbert. It is about three or four hundred yards up the little streamlet or "burn," at a point where it turns eastwards, and, as near as may be, 130 feet above the sea-level. Here the water has cut deeply into the bank, exposing a cliff of clay 55 feet above the level of the "burn," but this is only to the point where the face of the cliff begins, and we estimate that it rises 50 or 60 feet higher.

This boulder clay is of the usual character, stiff, compact, and full of stones of various sizes, many of them distinctly striated. At one part a finer or more sandy bed, gradually thinning out, is intercalated in the clay, as shown in the annexed cut representing the section. Such lenticular beds are not uncommon in the boulder clays of the West of Scotland.



Scaur of boulder clay, overlying denuded boss of laminated fossiliferous clay, Tangy Burn Campbeltown.

a, Laminated clay.
b, Boulder clay.

The chief interest of this section consists in the fact that, contrary to the usual position of the boulder clay in the West of Scotland, here it overlies shell-bearing clay. The latter is dark grey in colour, and contrasts strongly with the overlying boulder clay, which is of a full reddish brown. The two clays are equally distinct in composition. Thus :—

Boulder Clay.		*Shell-bearing Clay.*	
50 per cent.	fine mud.	80 per cent.	fine mud.
27 ,,	fine sand (21) and coarse sand (6).	14 ,,	fine sand.
		6 ,,	gravel.
23 ,,	gravel.		

The shell-bearing clay, as exposed in this section, is seen standing

* First brought under our notice by Captain Kerr, formerly a member of this Society.

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up in the boulder clay like a boss or knoll, and has doubtless been brought to this form by abrasion. At the greatest part visible it is 13 feet high, and it can be traced as it thins down along the edge of the streamlet for a distance of 60 or 70 yards. Its exact depth could not be ascertained, but as the rock is seen at a short distance on either hand, it is probably not more than a few feet deeper than what is exposed.

The fossils in this deposit are but thinly met with—molluscs, in particular are comparatively rare—*Leda pygmæa* being the prevailing shell, with an occasional *Leda pernula*, *Venus ovata*, and a few fragments of other species. These were submitted to Mr J. Gwyn Jeffreys, and at least two of them have proved to be of much interest—viz., *Pecten Grœnlandicus* and *Montacuta elevata*.

Pecten Grœnlandicus has been met with on the east coast, at Montrose, Errol, and Elie; but not before in the West of Scotland. It is remarkable that at Montrose it is only obtained at a great depth—seldom less than 30 or 40 feet; but at Elie it is met with only a few feet beneath the surface, and within reach of the tide; while at Tangy, as has been stated, it is 130 feet above the present sea-level.

Montacuta elevata is an Arctic species, and new to the glacial clays of Britain.

Ostracoda and Foraminifera are more numerously represented in this deposit, 18 species of the former and 23 of the latter having been obtained. It is to be remarked also regarding the Ostracoda, as we have already had occasion to do regarding the Mollusca, that they have much in common with those found in the clays on the east coast of Scotland, which are held to represent more strongly Arctic types than those generally found in the west. Amongst these are *Cytheropteron Montrosiense*, *Cytheropteron vespertilis*, and *Cytheropteron Sorbyana*. None of these has hitherto been met with in the clays of the West of Scotland, with the exception of one specimen of *C. Montrosiense*, which was found in the excavations for Messrs. Randolph & Elder's new dock near Govan.* *C. vespertilis* and *C. Sorbyana* are common species in the clays of Norway.

* This specimen was found, along with other Arctic marine shells, at a depth of 18 feet, in a lower bed of clay dipping away from the river. An upper bed, which dipped to the river, contained only more recent forms common to our raised beaches and present seas, such as *Pecten opercularis*, *Trochus umbilicatus*, &c. The operations at this dock having been suspended, the place soon filled with water, preventing further investigation for the time.

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We may here allude to two deposits in the north of Ireland, which we have had an opportunity of visiting, under the guidance of Mr. S. A. Stuart of Belfast—viz., Knockburn, about a mile to the south of that town; and Woodburn, near Carrickfergus. In the clays of Knockburn we obtained *Cytheropteron Montrosiense*, and the same species in Woodburn, together with *C. vespertilis*.

We are doubtful as to the position of the clay in the latter section, it being overlaid by a bed of coarse gravel; but at Knockburn, which was best exposed at the time of our visit, the overlying bed seemed to be of a loose boulder clay. We reserve a fuller examination of these sections till a future opportunity.

In connection with these remarks on the Tangy deposit, we may also refer to the finding of a shell of Arctic type (*Leda arctica*) in the clays from a pit in Ayrshire—Lucknow Pit, Ardeer Ironworks—as recorded in the Society's Transactions, Vol. III. This shell has not been found elsewhere in the west of Scotland, but is moderately common in the clays of Elie, Fifeshire, and abounds in the clay at Moss Tile-Works, in Norway. It is also living in the northern seas.

Taken along with the well-known Kilmaurs and Croftamie beds, the deposit in Tangy Glen seems to be another well-marked instance of marine clay with Arctic shells underlying boulder clay; and we have no doubt, as there are now more workers in this field of research, that additional instances of the same kind will be disclosed.

We respectfully urge the members to lose no opportunity of obtaining information from borings or cuttings in these post-tertiary deposits, as until they are more thoroughly known at all depths over the whole country, no satisfactory conclusion can be arrived at regarding them.

LIST OF SPECIES FROM TANGY GLEN.

MOLLUSCA.

Pecten Grœnlandicus, Sow.	One fragment.
Leda pygmœa, Münst.	
—— var. *Gouldii*.	Common and in good condition; mostly covered with ep.
Leda pernula, Mull.	Rare; mostly fragments, a few of which were less or more water-worn.

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Montacuta elevata, Stimp.	One very young, with the valves together.
Venus ovata, Penn.	Rare in the glacial clays of Scotland.
Corbula gibba, Olivi.	One valve.

No univalves have been met with in this deposit; they are also rare in the clays on the east coast.

POLYZOA.

Crisia eburnea, Ellis.	Moderately common.

CRUSTACEA.

Verruca Strömia, Müll.	A few plates.

FORAMINIFERA.

Cornuspira foliacea, Phill.	One.
Biloculina ringens, Lamk.	Moderately common.
——— *elongata*, D'Orb.	Moderately common.
Quinqueloculina seminulum, Linn.	Moderately common.
——— —— *subrotunda*, Mont.	Moderately common.
Lagena sulcata, W. and J.	Two.
—— *lævis*, Mont.	Two.
—— *Jeffreysii*, Brady.	One.
—— *gracillima*, Seg.	Four.
—— *globosa*, Mont.	Two.
—— *marginata*, Mont.	One.
—— *squamosa*, Mont.	One.
Vaginulina legumen, Linn.	One; large and fine.
Polymorphina compressa, D'Orb.	Common.
——— —— *lactea*, W. and J.	One.
—— ——— var.	Two.
Globigerina bulloides, D'Orb.	Moderately common.
Cassidulina lævigata, D'Orb.	Moderately common.
Discorbina globularis, D'Orb.	One.
Truncatulina lobatula, Walker.	Four.
Rotalia Beccarii, Linn.	Three.
Polystomella crispa, Linn.	One.
——— *striato-punctata*, F. and M.	One.
Nonionina depressula, W. J.	Common.
——— —— *asterizans*, F. and M.	Two.

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XI.—*On the* Glacial Deposits *of* North Ayrshire *and* Renfrewshire. By Robert Craig, Langside, Beith, *Corresponding Member.*

(Read 5th March, 1872.)

In the north of Ayrshire, the glacial deposits are well represented, especially around Kilmarnock, where they reach a depth of from 50 to 100 feet. In the higher localities they are found less regularly dispersed, chiefly filling hollows and ravines in the Trap hills, and "wants" along the outcrop of the Carboniferous strata. In the lower, or seaward end of the valleys, they are more regular, having an average depth of about 50 feet. The Renfrewshire deposits are very similar to those of Ayrshire.

The glacial epoch, according to a division first proposed by Professor Ramsay, and now all but generally concurred in, may be viewed as embracing three distinct periods:—1st, a period of land ice; 2nd, a period during which the land was submerged, and drift ice prevailed; 3rd, a period during which the land was re-elevated and local glaciers existed, producing a restricted or local glaciation.

In the district under review, the glacial deposits belong to the first and second periods, and may be roughly divided into the following groups:—

1*st*, *Lower till*—the produce of land ice; subjacent rocks all polished and striated; general striation from N. by E. to S. by W.; the mineral constituents agreeing with this, except a few erratics. This bed has suffered greatly from denudation, being now found in fragmentary bosses and patches.

2*nd*, *Sedimentary beds*—fragments of old land surfaces, and lacustrine remains; fossiliferous; fossils, all belonging to the land or fresh water; existing in very small patches, having been all but swept away by the subsequent submergence.

3*rd*, *Higher*, or *upper boulder clay*, containing intercalated beds of sand, mud, or gravel; general glaciation from N. by W. to S.

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by E.; mineral constituents not uniform, rocks of opposite directions being found mixed together, and the erratics more plentiful and altogether larger than in the lower bed. Deposits of this group probably due to marine agency and drift ice.

4th, Shell beds of the Clyde: conditions truly marine. The sea comparatively free of ice.

5th, Sand and *gravel beds* running into and forming mounds.

In the above sequence of deposition I am aware of adopting a system different from that held by high authorities; but from the evidence collected from all parts of the district, I have every confidence that the main views expressed will ultimately be verified. Before proceeding to adduce the reasons that have led to the above conclusions, I will give a slight description of the sections to which the table of boulders, appended to the end of this paper, refers.

The first column in the Table refers to the cutting at *Garval Park*, Greenock. That section has already been described by Mr. David Robertson, in the "Transactions" of this Society, Vol. IV. Suffice it to say that the boulders counted were taken from about 20 feet below the surface, where they were not so large as those found in two "roads" that crossed the dock at an oblique angle, or nearly N.W. and S.E. These roads were conspicuous and easily detected after the dock had been cut out, both from a slight difference in the colour of the clay, and the large size of the blocks protruding from the walls of the cutting. These large blocks were old red sandstone, and mostly of a grey variety, found plentiful *in situ*, on the shores of the Clyde, below Greenock. It was no easy matter to count them with accuracy; but an attempt to do so gave the following results:—Grey sandstone, 95 per cent.; schists, 3; granite, 1; and porphyrite, 1. The limestones in the table were all of the Loch Thom variety. At no place in the section was the rock reached; therefore, no striations being visible, it is impossible to determine the ice-flow from this source, and the mineral constituents are such as are found both to the N.W. and N.E.

Plaintreeyetts.—The boulders under this heading are from a small cutting on the Ayrshire and Greenock Railway, on the above farm, near Kilmalcolm. The boulder clay is a mere patch, lying on the N.W. end of a rock cutting. The subjacent rock was well polished, and striated from N.W. by N., 45° magnetic. The

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majority of the boulders correspond to the rock formation of the district, which is porphyritic, interbedded with melaphyre.

Seedhills, Paisley.—The column under Seedhills refers to a very interesting section of boulder clay, overlying a quarry at this place. The quarry, which is wrought for commercial purposes, is opened in a bed of eruptive dolerite, belonging to the base of the carboniferous series, or rather has been erupted out through this base, causing an upheaval and displacement of strata. It has a thickness of from 22 to 25 feet, with a dip of 38° to the S.E., the trend running nearly N.E., and I believe is the same bed that crosses the Clyde at Elderslie. The majority of the dolerites belonged to this bed, which crops out about 100 yards from where the boulders were counted. The section being surrounded by carboniferous strata, the boulders belonging to this series may have come from any point of the compass; but the rock beneath the clay is beautifully polished, and striated in a most interesting manner. On the east side of the quarry, under a ledge of rock that faced the east, the only striations visible were from the N.E. by N. Above the ledge, and where the surface was very rough and irregular, rising in steps towards the west, cross striations were visible, one with the above trend, and another from the N.W. by W., which proved to be the newer, or latest set. As the quarry was wrought towards the west, the latter set was seen to become bolder, and the former fainter, until the set from the N.W. had entirely obliterated the N.E. set, and the surface remained finely polished and striated from the N.W. by W. Whatever moraine may have covered the older glaciation, has been all removed and mixed up with the newer, except the very small patch that had preserved the old set under the protection of the small ledge of rock. As this was removed before I saw the section, no opportunity of comparing the difference of the clays was afforded. That the mineral constituents of the bed have come from the N.W. is shewn by the boulders, as well as from the direction of striations. On turning to the table, it will be observed that the second highest class of boulders is from the old red sandstone. These are 21 per cent. of the whole. Of these 17 per cent. were of the grey variety, and 4 per cent. of the red. The nearest old red to the section is the outcrop at Newark, Port-Glasgow, 12 miles distant, in a N.W. direction. The two varieties were identical with those found at Garval Park, and one or

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two limestones were decidedly of the Loch Thom variety. All the other limestones were traceable to the carboniferous series of Renfrewshire, which crop out in various places around the section, at a few miles distant. Among the metamorphic class I put a few syenites, of a variety found only here, and at Orchard, in Renfrewshire, and Kilmaurs, Ayrshire. These were larger than any of the other boulders; one of them, at Paisley, was 6 feet 8 inches long, 4½ feet broad, and 3½ feet high, rounded and polished into an elliptical form. The basalts were also erratic, none of the variety being found in the district, that I know of.

Nethertrees, Lochwinnoch.—In making the new water-works for Paisley at this place, a large area of boulder clay was removed for embankment purposes. At no place was the portion removed above 12 feet deep, but both the upper and lower clays were on. In some parts the two beds were divided by thin layers of sand, from 4 to 5 inches thick; at other places there appeared to be a mixture of both beds. The subjacent rock, a soft porphyrite, was polished and striated from the N.E. to S.W.; faint cross striations being visible beneath a part of the boss of boulder clay that faced the west. These cross striations were from the N.W., but they extended only for a few yards; the N.E. set becoming the only striations beneath the boss, as it was removed towards the east. The boulders, as given in the table, are a mixture from the two beds. The clay being used for puddle, all the stones were picked out of it and stored behind the cuttings; and it was from this heap that the per centage was made up, above 1000 being examined for this purpose. In the upper bed a few porphyrites of the Cuffhill variety were found. None of these occurred in the lower bed overlying the N.E. striations. The nearest point from the section where this rock is *in situ* is ¾ of a mile to the W.; but the majority of porphyrites were traceable to a rock found about a mile to the N.E. The Melaphyres, Anamesites, and Basalts are found both to the east and west of the section, and the same may be said of the Carboniferous boulders, but one variety of limestone was traceable to a bed near Paisley, 8 miles to the N.E. The erratics are rather high—the old red being 11 per cent., and the metamorphic 12; of the former, 5 per cent. are of the grey variety and 6 of the red. One species of old red found here and at Langside, Beith, agrees very closely with a description of old red found *in situ* at Dalreoch, Dumbartonshire. Among

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the metamorphic class were four granites of the grey order, and a few felstones and granitic felstones. A number of large boulders of gneiss were found overlying the cross striations, and most likely belonged to the upper bed.

Langside, Beith.—A section of till has been removed at this place in working a limestone quarry. The underlying rock is polished and striated from the N.E. to S.W., and the great majority of the local boulders agree with this. This quarry lies on the very edge of the carboniferous strata, as they crop out against the trap hills on the north. On turning to the table, it will be found that nearly 30 per cent. of the boulders found here are porphyrites. Of these, 17 per cent. belong to the variety common to the hills lying on the north of the section, 7½ to Cuffhill, ·75 to Gleniffer, and 7½ to the unknown variety. I am now of opinion that this variety of porphyrite is an erratic. They are found around, and to the north of, Beith. A few of them were found at Paisley, but not one of them in the cuttings between Stewarton and Kilmarnock. Of the other local boulders, the Dolerites and Melaphyres are a decimal over 9 per cent. each, the Anamesites 4, and the Basalts 2½. The latter class were all traceable to Barcud, or Barcraigs, lying 2½ miles north-east from the section. The dolerites belong to the dykes that intersect the strata to the north-east, but two boulders were traceable to a bed of intrusive greenstone, found at Slates, 3 miles west of Paisley, and about 9 miles north-east from Langside. The section being on the edge of the limestone outcrop towards the north-east, the boulders of this group are low, being only 3½ per cent., the sandstones 5½, and the ironstones a decimal over 1 per cent. The nearest beds of the latter two, to the north-east, is in the Howood mineral field, about 5 miles distant. The erratics are high—in fact, higher than in any other section examined in the district—being 31 per cent. of the whole boulders. Of this, the old reds are 24, and the metamorphics 7 per cent. Of the former, 15 per cent. belonged to the grey variety and 9 to the red; of the latter, in addition to the usual erratics placed in this class, there was found here a schistose conglomerate, rather plentifully scattered upon the surface of the ground, identical with a variety of boulder found at Planetreeyetts.

Little Windyhouse.—Following the ice trend, the next section examined is a cutting on the Beith Railway on the above farm.

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This cutting has been excavated since the paper upon the "Boulders found in the Beith Railway," &c., was read, and as the section is an interesting one, I think the facts observed worthy of preservation. The cutting at the point under remark was 18½ feet deep, and consisted of three different beds of clay. These taken in descending order are as follows:—Brick clay (same as is found in the district), 3½ feet; brown boulder clay, 7 feet; boulder clay cut into 8 feet. In the brick clay no stones were found larger than one inch in diameter, all rounded, but without striæ. In the brown underlying clay were found angular boulders, polished slightly, and faintly marked with striæ, few of them reaching 6 inches in diameter. This was not a regular bed, but apparently a patch about 60 yards long, filling a hollow in the underlying bed. It was in the bottom of this patch where the angular boulder was found, mentioned by Mr. Milne-Home, in his "Estuary of the Forth," &c. This angular block, 4½ feet long, 2½ feet broad, and 1½ feet high, had neither polish nor striae upon it. It belongs to a bed of limestone that occurs near the bottom of the "Hillhead," or upper beds of the Beith limestones, and is found *in situ* about 500 yards, both to the north-east and north-west, although I think it is from the latter direction the boulder in question has been derived. So small has been the friction caused by its transportation, that a layer of soft shale attached to the lower surface was as fresh in appearance as if newly removed from its parent bed in the quarry. Another angular block, larger than the above, from the same bed, was found in the same patch, and which showed neither polish nor striation, except upon one side, where a small surface was partially polished and faintly marked with striæ. As noted, with few exceptions, the boulders were small, their appearance being very much as if the debris accumulated in a quarry from working (the "shivers" of the quarryman) had been picked up and mixed into the clay. This was specially the case with the limestones, few of them having received as much polish as to obliterate the marks of fracture. The line of division betwixt this patch and the superincumbent brick clay was well defined. Small balls of peat were found at intervals in the line, and at one place a fragment of oak was found, much worn by friction; its length was 3 feet 9 inches, breadth 8 inches, and thickness 3 inches. In the bed underlying the 7 feet patch of brown clay the boulders were all polished and striated. On turning to the table, under

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Little Windyhouse, 1*a* represents the boulders in the brick clay; 2*a* those of the brown patch; and 3*a* that of the lower bed. Of the Porphyrites there were found 11 per cent. in the former, and 10½ in 2*a*, and 12½ in 3*a*. In the two former no Cuffhill occurs, while 3 per cent. of this variety is found in the latter. Of the Melaphyres 33 per cent. are found in the brick clay, none in 2*a*, while in the lower bed 6½ occur. The dolerites vary a little in the three beds, being 11 in the brick clay, 16 in the brown patch, and 9 per cent. in the lower bed. In the brick clay no limestones were observed; in the patch (2*a*) 16, and in the lower bed 52 per cent. were found. Of the former, the whole of the boulders of this class belonged to the bottom beds, from which the large angular blocks had descended, while 46 per cent. of the latter were from the Productal and Encrinital beds lying on a higher horizon at Broadstone. Of the carboniferous sandstones, 15 per cent. occur in the brick clay, 26 per cent. in the patch, and barely 6 in the lower bed. Of old red sandstones, the brick clay produced 11 per cent., the patch none, and the lower bed 5 per cent. None of the other erratics were found in any of the beds. The marked influence of strata upon the boulders is well brought out by comparing this section and that at Langside, about 1¼ mile to the north-east. Langside, lying upon the outcrop of the limestone, gives 3½ per cent. of this class; while Windyhouse, more to the south-west, with limestone forming nearly the whole surface strata between the two sections, gives 52 per cent. of limestone boulders.

Roughwood, Beith.—In this quarry both of the beds are on; the higher bed resting upon the rock, overlying striations from N. by W. 15°, the lower bed resting upon a finely-polished and striated surface, the striations bearing N.E. to S.W. 40°. The latter bed is full of large rounded and subangular boulders of limestone, from beds lying to the N.E. The upper bed is almost free of limestone boulders, and contains very few large boulders of any kind—the boulders being small and gravelly, with the exception of an erratic dolerite found near the top of the bed. I do not know a section where the two beds can be better studied than here. On the west side of the quarry the upper bed rests upon the rock, which is partially polished and striated; on the east side both beds are on, the upper resting upon the lower, with no intervening beds. At one place a thin bed of water-rolled shale

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lay in the line of division, and in the bottom of the upper bed a species of moss was found.

On turning to the table, Roughwood, 1*a* gives the boulders in the upper bed, and 2*a* those of the lower. The porphyrites are 14 and 8 per cent.; the melaphyres, 14 and 2; anamesites, 22 per cent. in the upper, and none in the lower; limestones, none in the upper, and 55 per cent. in the lower; sandstones, 11 in the upper, and 5 in the lower; ironstones, 3 in the upper, and 13 in the lower. No old red was found in the upper, but about 4 per cent. of schists; and in the lower bed 1½ of old red were found, but no schist or other kind of erratics occurred.

Overtoun.—In this quarry a most interesting section was laid open. Both the upper and lower beds are on, with an intercalated bed of sedimentary clay. The striations upon the rock surface, which is finely polished, are from the N.E. Upon these the lower bed rests, and is full of stones of all sizes, rounded, polished, and striated, from rocks found lying in the ice trend north-east of the section. In the upper bed, boulders from the same source are found, but mixed with others from an opposite direction. As at Roughwood, and wherever the upper bed is found in this locality, the boulders are all smaller than in the lower bed, if we except a few large angular blocks of a dolerite found in the surface of both beds, and which is, I believe, an erratic. In addition to the local boulders common to the lower bed, there are found in this higher bed blocks of calcareous shale, whose parent bed is found at Broadstone, three-fourths of a mile to the south-west; and also an argillaceous shale common to the coal and ironstone measures. The calcareous shale is found in large blocks, very slightly polished, and mostly angular; the clayey shale small, and having a water-worn appearance. At one place the higher bed was much mixed up with pieces of the underlying sedimentary clay. The latter had been taken up in lumps, and was found in the higher bed in all sizes, from that of wafers to lumps a foot in diameter. This was also found in a similar section at Hill-head, Beith. A bed of sedimentary clay was here found running beneath a bed of this higher boulder clay, and, in the course of working the quarry, the latter bed, about 7 feet thick, was found to contain lumps of the former, some of them a foot square, full of the roots and stems of the common hazel, they being very plentiful in the parent bed.

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The sedimentary bed at Overtoun filled an elliptical basin about 130 yards long, and about 30 yards broad, and ran from one to two feet deep. The three beds were not in superincumbent position. The sedimentary bed overlaid the till on its north-east end, and was itself overlaid on its south-west end by the higher bed of boulder clay. Neither here nor at Hillhead did these beds extend to any great distance below the higher bed; they both thinned off in wedge form at a distance of about 30 feet from where the latter beds came on. That this had not been the original termination of the bed, at least at Overtoun, was proved by the working of the quarry. As far as the quarry was wrought to the south-west, evidence of the sedimentary bed was found, having at one time overlaid the limestone to that extent. As far as the sedimentary bed extended beneath the boulder clay, it was found to be full of the stems and roots of the common hazel, and after it ran off, the "cutters" or fissures of the limestone were filled with the clay, and were full of the roots of that shrub. That these had grown in the position in which they were found, and had not been washed in, was evident from the flattened roots, which had accommodated themselves to the size of the cutters. Roots and stems were plentiful throughout the whole of the bed; and at one place, where some thin flaggy shale which overlies the limestone had been forced over and into the clay, stems or skeletons of fern fronds were found rather plentifully, none of which were preserved, along with nuts of the hazel, some of which have been secured.

The sedimentary bed at Hillhead was very similar in character to the one at Overtoun. It appeared to be the fragment of a larger bed which had been destroyed by the agent that deposited the overlying bed of boulder clay. Like the bed at Overtoun, it was full of hazel remains; and in the lumps of this clay that had been taken up and embedded in the overlying boulder clay, these remains were found as undisturbed as those in the parent bed. In a parcel of the higher bed of boulder clay from Overtoun, washed by Mr. David Robertson, a species of fresh water *Ostracoda* was found. The parcel was taken from a part of the bed that was much mixed up with the sedimentary clay, and I am inclined to refer the *Ostracoda* to this clay. In two parcels taken from the same bed, but where it was free from the sedimentary clay, no fossils were found. Mr. Robertson washed a parcel of sedimentary

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clay, but it yielded no animal remains. The parcel was taken from a part of the bed where it was overlain by peat, and this may account for their absence. These sections at Overtoun and Hillhead are of interest, as showing that some of the small basins of brick clay which are scattered throughout the country are interglacial. But for the working of the quarries, these two little basins would have been called postglacial; but the workings clearly showed that thay were overlapped by a bed of boulder clay.

Kilmarnock District.—The boulders in the table from this district are mostly taken from the cuttings that have been opened in making the railway from Neilston to Kilmarnock. Some fine sections of till have been thus laid open for investigation. The line enters the carboniferous strata near Shelford, Neilston, and runs along its eastern outcrop to Kilmarnock. At Kilmaurs it intersects a boss of intrusive dolerite, that runs nearly parallel with it to Kilmarnock, at a short distance to the north-east; and it will be seen from the table that the dolerites are highest on this part of the line. At the north end of Stewarton, the rock is polished, and striated from E.N.E.; and in the present quarry at Woodhill a small surface of preserved striæ were N.E. to S.W. At Waterland, Dunlop, the striæ are from N.E. to S.W., and at Symington, a few miles south of Kilmarnock, they have the same trend; so that the general striation under the lower till in this locality may be taken as coming from a north-eastern direction. As will be seen from the table of *striæ* at the end of the paper, this is the general direction in the district under review. Both the upper and lower boulder clays, however, are on in this part of the district, and, from a certain class of boulders found in the upper bed, are apparently much mixed together.

Peacockbank, Stewarton.—The first cutting after leaving Stewarton, to the south, is the one formed for turning the public road on this farm. It has a depth of 18 feet, and is about 300 yards long. On the top of the cutting a yellowish brick clay occurred, $3\frac{1}{2}$ feet thick. The underlying 15 feet had all the appearance of true till; but from boulders being found in it, especially near the top of the bed, that had come from opposite directions, it may be accepted as a mixture of both tills. The majority of the boulders were traceable to local rocks lying to the north-east; but of the porphyrites, 7 boulders were from Gleniffer (north), and 5 from

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Cuffhill (north-west); and two boulders of the white encrinital limestone from Beith, which may have come from any point between west and north. All these boulders had travelled a distance of about seven miles.

Horsemuir Cutting.—A small section of the upper beds was cut into on this farm. The only thing notable is the falling off of the limestone boulders to 1½ per cent. The clay was very gravelly, and the boulders all small, few of them reaching one foot in diameter.

Flowers.—This is a large section, about ¾ of a mile long and 25 feet deep. It has all the characteristics of the true till in the bottom of the cutting, but on its north end patches of laminated clayey sand were found, full of sandstone pebbles, and on its south end lay a bed of the upper boulder clay, holding pieces of a soft blue clay, very similar to what has been noticed at Overtoun, Beith. This clay was of a reddish colour, and more friable than the underlying bed. A layer of large boulders of dolerite marked the line of division between the two, and in the upper bed two stumps of oak were found perpendicular to the horizon, and in every respect similar to the one found at Manneraheads, Beith. The columns in the table under this heading refer to three points in the section where the boulders were counted. 1*a*, is from the north end of the cutting, and were taken out of the upper 15 feet. 2*a*, is also from the north end, but are from the under 10 feet of the section. 3*a*, is from the south end, and is a mixture from both beds, having been taken from the *bing*, or heap, thrown behind by the excavators. On turning to the table, it will be seen that the porphyrites are the highest class in all the columns, and this quite agrees with the petrography of the locality. To the north-east a boss of porphyrite extends to within one mile from the cutting, and from this source a little above one-third of the boulders have come. It will be seen that this class is highest in the bottom of the section, but that the dolerites are higher in the upper than in the under part, and that the limestones are the reverse of this. In the north end of the cutting no ironstones are found, while the south end gives 2½ per cent, and this agrees with its position in the locality.

Wheatrig.—This refers to a small cutting, through a boss of gravelly sand on this farm, lying betwixt the cutting at Flowers and the following one at Towerhill, and is only introduced here

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for the purpose of comparing the boulders of the gravel mounds with the boulder clay in their vicinity.

Towerhill, Kilmaurs.—This is a long cutting, running from 10 to 15 feet deep, and about half-a-mile long. The most noteworthy thing in it is a trough of different clay from that which constitutes the material of the main section. This occurred in the cutting a little to the north of Towerhill House, and crossed the railway at an oblique angle, running NN.W. and SS.E. It was about 80 feet broad, and was cut into 15 feet without reaching its bottom. The section was not conspicuous for large boulders, except upon its south end, where a pavement of large dolerites lay upon the top of the till, and below four feet of the usual brick clay; but in this trough the boulders were all larger, and among them a few syenities of identical character with those found at Paisley and Orchard. The majority of the other boulders in the trough were dolerites of a finer grain than those of this class found in the other part of the cuttings, but identical with a class of dolerites found associated with some large erratics that occurred in the cutting about 200 yards to the south of this. In this cutting, on its south end, 7 per cent. of ironstones were found. They were all from a bed about 8 inches thick, and showed little of either polish or striæ. From this section, on to Kilmarnock, the porphyrites decline and the dolerites increase; and this is in accordance with the rocks lying to the north-east. As already mentioned, a boss of intrusive dolerite runs along the north-east of the line, at an irregular distance from it, on to Kilmarnock. Also, in this section was first found a porphyritic tuffa, which I have marked in the table "tuffa." It is identical in character with a tuffa found at Darvel, but may belong to a class of tuffas that are interbedded in the intrusive dolerite on the north-east. Still, the only tuffa of similar character known to me is one above Darvel, 10 miles to the east.

North Woodhill.—This cutting lies about 300 yards north from the old Woodhill quarry, where so many mammalian remains have been found. The section is throughout a boss of lower till, 300 yards long, and cut into 26 feet. But on the north-west side of the boss, and across its top, lies a bed of the boulder clay, V. of the following section. On the south-east side lies a patch of the bed VI. Both of these rest upon the lower till, and were nine feet thick; but the bed VI. overlapped the bed V., which was seen

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terminating in a wedge-like point between the beds I. and VI. The following is a section of the glacial deposits of the district that may be accepted as typical, taken in ascending order:—

		Feet.	In.
I.	Lower till, thickness irregular, about - - -	30	0
II.	Gravelly bed, - - - - - - - -	1	6
III.	Sandy peaty clay, with mammalian remains, -	1	3
IV.	Sand bed, with Arctic shells, - - - -	1	3
V.	Higher or upper boulder clay, thickness irregular, about	40	0
VI.	Earth clay, full of water-worn stones, do., do.	20	0
VII.	Brick clay, thickness irregular, about - - -	5	0
VIII.	Valley gravel, do., - - - - - -		
IX.	Peaty sand, do., - - - - - -		
X.	Fine sand, with clay, do., - - - - - -	40	0

In no single section that I am acquainted with are the whole of these beds in superposition, but they are all found in the district, lying in the position here specified. The till (I.) appears to have been highly denuded, and is now found only in small bosses, apparently forming the nucleus of the large bosses in the district, as at North Woodhill, Fardlehill, &c. It is altogether harder and tougher than the superincumbent beds, although not differing much in mineral constituents. It is often eroded upon its upper surface, and having the eroded hollows filled with the overlying clay. In the present Woodhill quarry, a place of the form of the letter V, 5 feet broad and 4½ feet deep, crossed the surface of the lower bed, running N.E. and S.W. This was filled with the bed VI., which rests upon the lower till here. The beds II., III., and IV. are only found in the old Woodhill quarry, and in two pits in the vicinity. They soon lose their distinctive character, and are found as a sand bed, running from 4 to 18 feet in thickness. They occupy a hollow, of no great breadth, that runs a little to the north of the present Glasgow and South-Western Railway, from the old quarry to near Bonington farmhouse. For an account of the fossils that these beds have produced, see the Transactions of this Society (vol. i., p. 69, and vol. iii., p. 314, *et seq*). There is some difficulty in placing these beds in the position that I here assign to them, but as there are three boulder clays, all differing in character, and as the fossiliferous beds have always been found underlying the higher bed (V.), and have never been found underlying the lower bed (I.), I have, after some hesitation, placed them upon a higher horizon than the lower bed of till. In

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one bore put down in the track they occupy, boulder clay was found underlying the sand bed. The higher bed of boulder clay (V.) is altogether of a softer nature than the lower bed (I.), and, although full of boulders, runs at some places into a soft mud showing faint lines of lamination, and very free of stones. A number of the boulders in this bed are covered with a sandy calcareous encrustation which I have never observed in the lower bed. In a pit recently sunk on the farm of East Woodhill (No. 13), Mr Yeats, jun., found fragments of two shells in this bed, about 42 feet from the surface, and 30 from the bottom of the till. One of them, an *Astarte sulcata*, was preserved, but, unfortunately, the other was mislaid before it was identified. This is the principal bed of boulder clay in this district, and appears to be partly a re-arrangement from the lower bed. It contains lenticular beds of sand and gravel, but, from parcels forwarded to Mr. Robertson for examination, it appears these contain no organic remains.

As already noted, No. VI. in the foregoing table is an earthy clay, with nests of sand, and full of water-worn boulders free of striations; and as it caps the other clays, it probably belongs to the valley gravel series, being characteristic of some of these.

Referring to the boulders in the table opposite North Woodhill,—I. is from the lower till, V. is from the upper bed, and VI. is from the higher earthy bed, the figures giving the same bed as in the section. No great difference takes place in the local boulders, in the beds V. and VI., except in this instance at North Woodhill, where the boulders were counted from a section of the upper bed V., on the north-west side of the boss. Here the erratics are 17½ per cent.; while in the bed I., lower till, taken 24 feet below the surface, they are only 3 per cent. Another difference in this upper bed, north-west side of the boss, is the high figure reached by the basalts, which are 30 per cent. —a class of boulders which are low in all these cuttings except in this instance. In the bed VI., taken from the present Woodhill quarry, the highest difference is in the Carboniferous Sandstones, which are 22 per cent. higher than in the lower bed I. No limestones are found in this bed, but as it is free to water they may have been dissolved by chemical action.

Woodhill and *Bonington.*—The cuttings throughout these farms are in the bed V., and the only thing noteworthy is the discovery

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of 6 per cent. of new Red Sandstone from Mauchline. These were all angular, and without either polish or striæ, and were found at from 4 to 8 feet below the surface—none lower—but all in the bed V. These cuttings have been valuable in throwing light upon a number of journals of bores appended, which otherwise would have been very puzzling.

The brick clays, with the valley gravels, peat, and sand, complete the glacial and connected beds in the district. The brick clay is a tough yellow, blue, or brown clay, almost free of stones, and is found filling small basins in the till throughout North Ayrshire. More of these little basins may be interglacial than are at present supposed. The one at Overtoun and at Hillhead was found to be so by the clearest evidence, and others may yet be discovered of similar character. The gravels, peat, and sand are found in the valleys, some of the beds in the valley of the Irvine reaching a thickness of 40 feet. A boss of sand and gravel, mostly fine sand, was cut into 33 feet 10 inches, without reaching the bottom, in making a new road from Newmilns to Darvel. A shell was picked up in this cutting, but I failed to trace it. These beds appear to be nearly unfossiliferous. Parcels forwarded to Mr. Robertson for washing yielded no animal remains. A soft, white, calcareous matter, found in a parcel of sandy mud from the banks of the Irvine, opposite Loudon Hill, Mr. Robertson thought might be the remains of a shell, but it was too much decayed either to identify or speak of with certainty.

Summary of the Evidence deducible from the foregoing Sections.—A careful examination of the glacial deposits in the district under review will convince the investigator that the boulder clay exists in two beds of different age, divided by sedimentary beds of land and fresh-water origin. The sedimentary beds found at Overtoun and Hillhead, described under that section, point to fragmentary remains of an old land surface that has been all but swept away by the subsequent agent that has crossed the country and deposited the higher or upper boulder clay. Although not described in this paper, I have shown elsewhere (in present vol., p. 24) that the old lacustrine beds in Cowden Glen are overlaid in three places by the upper bed, in natural position. The mammalian remains found in that locality, in the silt of the old lake, and in the peat bed that may be accepted as the land margin around it, form a strong link in the chain of evidence which

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proves that land, comparatively free of ice, existed at this time in the West of Scotland. The identity of the Ostracoda, found by Mr. Robertson in the Overtoun clay, with those found by him in the mud of the old lake in Cowden Glen, is another link that ought not to be overlooked in settling the contemporaneity of the two deposits. The plentiful remains of oak, birch, and hazel found in the intercalated sedimentary beds, and in the bottom of the upper boulder clay, at various places, are also clear proofs of land free of ice, and show that trees of no mean bulk flourished at the time. These indications of an old land surface, free of ice, although small and fragmentary, are still clear and distinct. The subsequent submergence which appears to have taken place at this time, has not only destroyed all trace of this old land surface, except fragmentary patches, but has also swept away the greater part of the lower boulder clay. The small bosses and patches of older till found throughout the district belong, in my opinion, to the *moraine profonde* of the older glaciation from land ice. But the greater part of this, along with all the terminal and lateral moraines that the melting of the ice would leave throughout the country, have been swept away and mixed up in the newer glaciation.

The two Glaciations.—The question arises, have these two glaciations been accomplished by the same agent, and in the same manner? While accepting land ice as the glaciating agent in the older, or N.E. glaciation, I am of opinion that the newer, or N.W. glaciation, has been the result of drift ice and marine agency. A close examination of the mineral constituents of the two deposits, has led me to this conclusion. In the small patches of the older till, the great majority of the mineral constituents are local, and have all come from a north-eastern direction. From an extensive and minute examination of the mineral constituents of the till, I find that 95 per cent. of the rocks found in it have come from rocks found *in situ* within a distance of five miles of their present bed. The most of them can be traced to rocks from one to two miles distant. Another important fact is the purity, as it may be called, of the mineral constituents in this older N.E. glaciation. They all come from rocks lying on the N.E. trend. There is no mixing up of rocks from the east and from the west, as in the newer, or N.W. glaciation. A few Old Red sandstones are found that have been transported from a distance, probably

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upon the top of the ice, with a few other erratics; otherwise the boulders are purely local, and from the N.E.

In the newer, or N.W. glaciation, all this is changed; local rocks are found in its deposits, whose parent beds lie both to the east and west of the section in which they occur, and erratics are numerous. These, although found in all parts of the deposits, are not so regularly dispersed in them as the local boulders, but lie more in "nests." Where a knowledge of the petrography of a locality exists, the age of the boulder clays may be known by the mineral constituents they hold. In the older glaciation, the boulders are purely N.E.; in the newer, are found rocks lying both to the N.E. and N.W., thus proving that the till overlying the N.E. set of striations is the older, and that resting upon the N.W. set the newer. In addition to the proof from the mineral constituents, the clearest evidence exists in the deposits themselves. Wherever the two deposits are found in superposition, those overlying the N.W. striations are always found overlapping those resting upon the N.E. set, and never *vice versâ*. Good examples of this were seen at Roughwood, Overtoun, and North Woodhill. Another section, corroborative of this, was lately laid open at *Braehead*, East Kilbride. The surface of the rocks in the various quarries in this locality that underlie the till is much rubbed and scratched in all directions; but in some places an older set, with a uniform trend from the N.E. by N., becomes visible. In working the above quarry during last winter, a fissure was laid open in the limestone, running N.W. and S.E., and 5 feet 9 inches broad. It was deeper than the bottom of the limestone (10 feet), and was filled with clay and large blocks of the upper bed of the limestone, which had been all pushed in from the N.E. side of the fissure, thus corroborating the conclusion that I had arrived at as to the age of the rather obscure striations in the neighbouring quarries, that the older was from the N.E. This was also found at Paisley, where the N.W. glaciation was seen to completely obliterate the one from the N.E. From the Table of Striations, appended, it will be seen that the N.E. striæ are found rising over the Gleniffer range of hills, to the S.W., 700 feet above sea level; and in the Johnstone and Dalry valley, which runs N.E. and S.W., but turns more southwards when near Kilbirnie, the striations are found rising obliquely across the hills towards their summits. The same occurs on Cuffhill;

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the striations are seen rising up over the hill. In the Lochlibo valley they are seen obliquely crossing it, near the west end of Lochlibo, and going over the Dunlop hills. All these are the older set from the N.E., which is more highly preserved in the North of Ayrshire and South of Renfrewshire than elsewhere in the Central Valley. Still, the N. by W. set is not wanting, and a large part of the till in the district belongs to the newer glaciation.

The reasons that have induced me to assign this newer, or N.W. glaciation, with its deposits, to the agency of drift ice, are various. In the older till, overlying the N.E. glaciation, the majority of the boulders are traceable to rocks lying on the ice-trend, not more than three miles distant from the section in which they are found—the highest number not above one mile. In the N.W. glaciation this does not hold; a large number of the boulders come from 12 to 25 miles, and more. Take the section of Seedhills, Paisley—and I know of no section where the newer deposits are so alike in character to the older patches as here—the mineral constituents, if we take them large and small, as they are found, are fully one-half erratic. In the table, where none were admitted below 6 inches in diameter, the erratics are 33 per cent., 24 being Old Red Sandstone. The nearest outcrop of Old Red is 12 miles distant to the north-west. Now, these could not be carried forward in the *moraine profonde* of land ice, and they are out of all proportion with anything yet found in this moraine to account for them, by being transported upon the upper surface of the ice, as I believe the erratics in till from land ice have been. A marked contrast to this section is that of Plaintreeyetts. Thus, while Seedhills at 12 miles distance from the parent bed, gives 24 per cent. of Old Red, Plaintreeyetts at a distance of not more than two miles from the outcrop, gives only 4 per cent.—a fact that would have been just reversed had their transportation been due to land ice. Both sections of till rest upon N.W. striæ, but Seedhills is about 40 feet above sea level, and Plaintreeyetts 346 feet. The outcrop of Old Red to the north-west of the latter is about 250 feet above the sea, and this may account for the difference of the two sections, if drift ice be accepted as the transporting agent. Long after Seedhills would be submerged deep enough to allow bergs to pass over it, Plaintreeyetts would remain dry, and before it became submerged so as allow bergs to pass over it, the Old

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Red would be deeply buried beneath the water, and this may account for the paucity of this variety of boulders in the section.*

In the newer till a large number of fragments of wood are found. In the paper already quoted, I described two pieces of oak that were found perpendicular to the horizon. In the cutting at Flowers, two pieces similarly situated were found, the one about 8 feet below the surface, and the upper end of the other only 2 feet. However these were transported, it could not be in the *moraine profonde* of land ice. These perpendicular fragments show no polishing, while those found in a horizontal position are much worn by grinding. In the older till no fragments of wood are met with, neither do sand and gravel beds occur in it. These are plentiful in the newer till, and go far to establish its glacial-marine origin.

In the Table of Bores, appended, it will be seen that mud and sand beds are found intercalated in the till at different places in the district, and beds of the same are found underlying it also, some of them of considerable thickness. As regards these subjacent beds of mud and sand, I am inclined to place them all in newer till, along with the intercalated beds referred to. A short study of the bores, along with a map of the district, will convince any one that these beds of sand, mud, and gravel are not regular beds, but lenticular patches, many of them of small extent. In the Bonington cutting one of these nests was cut through. It was about 100 yards long, and 3 feet deep in its greatest thickness,

* In the Seedhills section some large boulders of Syenite were found, and at Kilmaurs, in Ayrshire, boulders of identical character occurred. At Kilmaurs these occurred in a basin of till of different character to that which surrounded it. These erratic Syenites were not surface boulders, as may be supposed, but were deeply embedded in the till. At the latter place they were found 15 feet from the surface, and at Seedhills 20 feet of till overlaid them. In the paper "On the Boulders in the Beith Railway," &c. (Trans., Vol. IV., p. 45), in giving the boulders in the Thirdpart cutting, I mentioned that at Langside the erratics were 24 per cent. of the whole boulders. Both of these sections rested upon striæ from the N.E., and at one time I looked upon the clay in both as lower till, but I am now convinced that both sections are upper drift, or newer till. They both lie upon the north-west side of bosses of till whose nucleus may be the older deposit, but the place from which the boulders were counted is of newer character. The same occurred at North Woodhill. The railway is there cut through a boss of till to a depth of 26 feet. On the north-west side of the boss the till contained 17 per cent. of erratics, including a few Arran granites, while in the centre there only occurred 3 per cent. The line of division was well marked here between the older and newer till, which differed so largely in the erratic boulders. In the nucleus of the boss no granite was found, only 1 per cent. of Schist, 2 per cent. of Old Red, and 1 of Basalt. On the north-west side, beside the 17 per cent. of erratics, 30 per cent. of Basalt was found; and as this is a rare boulder throughout all these cuttings, the large number of them here are, without doubt, also erratic.

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thinning off to nothing on the two ends, although continuing in the boulder clay as a line of sand, about an inch thick, for another 100 yards. This, had it been in a bore, would have been set down as a bed, while in reality it was nothing more than a "nest."*

In thus placing nearly the whole of the boulder clay in Scotland, and, from what follows, that of England and Ireland, in the category of newer till, deposited from a newer glaciation by drift ice, as contra-distinct from till by land ice, I am aware I adopt a conclusion at variance with the views at present advocated by the leading Scotch geologists; but in doing so I only follow the conclusions which the evidence, so far as I have been able to trace it, has led to. The universality of the older set of striations from the N.E., moving across valleys and rising over hills, some of them

* From these so-called intercalated beds, found in the till of the central valley, some Scottish geologists advocate as many breaks in the glacial period as intercalated beds are found in the till. If I understand these periods of "break" aright, they mean intermittent periods of warmth, when the glaciers or masses of land ice were withdrawn. The layers of sand, mud, or gravel were then deposited, and the superincumbent bed of till is evidence of the return of the glacier. It has always appeared to me that this theory will not bear investigation, and that its advocates have overlooked an important point in the evidence—viz., the lenticular character of the beds.

Mr. James Bennie, in his excellent paper "On the Surface Geology around Glasgow" (Trans., Vol. III., p. 133), notes 11 bores which give a number of intercalated beds, which he accepts as evidence of "breaks" in the glacial period.

As Mr. James Geikie, in his attempt to correlate the glacial deposits of Europe and America, gives these bores as typical of the Scotch glacial deposits (see *Geo. Mag.*, Vol. IX., page 65, *et seq.*), let us analyse a few of them, which will at once establish their lenticular character. Take the two bores at Millichin. In the one there are 18 beds passed through, viz.:—Sandy mud, 6 beds, having a combined thickness of 101 feet; 2 beds of sand, having a combined thickness of 29 feet; 2 beds of gravel, having a combined thickness of 34 feet; 6 beds of brown clay, having a combined thickness of 161 feet. In the second bore, which was about half-a-mile distant from the above, 5 of the beds are off, and 13 beds remain. These are as follows:—Sandy mud, 5 beds, with a combined thickness of 95 feet; sand and gravel, 2 beds, with a combined thickness of 48 feet. Here one bed of brown till is entirely off, and the others thinned away to one-third of the thickness they have in the first bore. But in three bores put down at Towncroft, near Grangemouth, as given by Mr. Bennie, we have more pointed results. These bores are on a line 300 yards long; one bore on each end, and one in the centre, and are 150 yards apart. In the southmost bore there are 4 beds of sand, 63 feet thick; in the centre one, 4 beds, 35 feet; and in the northmost, 4 beds, 48 feet. In the first, 2 beds of boulder clay, 157 feet; in the second, 4 beds, 108 feet; and in the third, two beds, 50 feet. Here, in about 150 yards, a bed of hard blue till, 140 feet thick, either thins off to 40 feet, and three other beds of hard blue till come on, or it has been mixed with intercalated beds of sand from 2 to 20 feet thick—a fact in itself sufficient to establish both the lenticular and glacial-marine character of these beds.

Mr. Milne-Home, in his "Estuary of the Forth," publishes journals of 30 bores and open sections, forming a valuable contribution to surface geology. In these the same results are found, clear evidence of the unpersistency of the beds of boulder clay, sand, mud and gravel, which make up the glacial deposits of the central valley. Thus, wherever these sand beds are found intercalated in the till, they are always found to be lenticular, the till thinning off as the sand thickens, and *vice versâ*.

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near 2000 feet high, speaks of no ordinary glaciers, but of a vast sheet of ice, moving from the north by north-east (general trend, N.E. by N. magnetic), and crossing the country to the south-west. The purity of the mineral constituents in the small patches of till overlying this glaciation, in their north-east origin, and the short distance at which they die out to the south-west from their parent bed, tell us in the clearest manner that the means of transport has been as a footboard beneath the ice, or in the *moraine profonde* of land ice. The evidence on this point clearly indicates a general glaciation from land ice, moving from a north-eastern direction.

In the deposits overlying striæ from a north-western direction, the mineral constituents are not so pure. Local rocks, lying both to the east and west of the section, are found mixed up together, and rocks lying to the north-west are plentifully present, from 10 to 50 miles from their parent bed. Striæ from a north-western direction are so general in this island, that nothing short of a general glaciation from that direction could have left such marks behind. It is the general glaciation in the central valley of Scotland; it is the general glaciation of Ireland; and it appears to be the general glaciation of England. Wherever its deposits are found, they appear to have the same character—mixed mineral constituents, and a number of erratics at a great distance from their parent bed. All this speaks of drift ice; and the sand beds, intercalated, of water. Few shells have been found in this Scotch newer till, except at Caithness; but recently, as already noted, two fragments were found in true newer till at Kilmarnock. This evidence is slight in amount, but still of importance, as pointing out the marine origin of the till.*

* The two sets of striæ have been observed in Ireland by Mr. J. H. Kinahan. (See *Geo. Mag.*, Vol. II., page 473.) In a short letter he points out that the primary striation of Ireland is from NN.E. to SS.W., and although he states that this has been succeeded by a secondary set, he does not indicate its direction, but in some remarks upon the Rev. Mr. Close's map of the glaciation of Ireland, he says that the secondary set is N. 30° W. These are very nearly the general directions of the two sets in central Scotland.

In the *Geological Magazine*, Vol. VII., page 350, and following, Mr. D. Mackintosh, F.G.S., has given the direction of striæ in the north of England, and here he also found primary striæ from a north-eastern to a south-western direction, and a secondary set from a north-western to a south-eastern one. In the Shetland Islands both sets have been noticed by Mr. Peach; and in Iceland the same has been observed. In the north of Europe both the late Dr. Robert Chambers and Mr. Murchison have noted the two sets.

A very important question arises on considering the generality of the north-western glaciation as found on the north-west of Ireland and England, and the isles to the north and west of Scotland. Where could the land ice come from if the north-west glaciation is due to land ice? This difficulty has been perceived

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Cross Striæ.—In some places both sets of striæ are visible, the one crossing and obliterating the other. These, wherever I have seen and followed them to a termination, are narrow belts of no great breadth, existing between the two general sets, where, from some inequality of the rock surface, the older has been preserved, and the grinding power of the newer has been stopped at this point, leaving its mark, but has not moved across the old set long enough to obliterate them. The belt at Paisley, where both sets were visible, crossing each other, was about 40 feet, and I have never seen the breadth more.

Local Glaciation.—In addition to the two general glaciations—the older from a north-eastern source, and the newer from the north-western—local glaciations are found in the neighbourhood of mountains, which must always be carefully noted by themselves, and not mixed up with the two general sets. It appears that much confusion exists at present about the true direction of the ice flow, from the want of carefully noting to what glaciation the striæ observed belong. Professor Ramsay, long ago, pointed out that the last glaciation of the country was local, from masses of ice descending from the mountains after the emergence of the land. Much of the glaciation of the Highlands appears to belong to this third glaciation, and until each set of striæ has its proper

by the advocates of land ice, and in the case of Caithness, which is glaciated from the north-west, Mr. Croll has attempted to show that it has been glaciated from the south-east. (*Geo. Mag.*, Vol. VII., pages 209 and 271.) To accomplish this, he supposes a glacier descending the Baltic, and another joining it from the Scotch central valley, and, thus combined, moving up the North Sea and over Caithness, and into the Atlantic ocean somewhere about the Orkney Islands. This might be accepted if the North Sea was clear of ice, but, if I have understood him, he shows that a sheet of ice, from 1000 to 2000 feet thick, filled the Arctic Ocean, the North Sea, and covered Scandinavia, Scotland, and the seas around it, terminating, in a perpendicular wall of ice, in the deep waters of the Atlantic, from the west of Ireland, away in the direction of Iceland. What kind of a glacier it was that moved up the North Sea against this enormous flow of ice, Mr. Croll does not exactly inform us; but as equals can only resist equals, we are left to suppose that the Scotch and Baltic glaciers, combined, were weighty enough to push back the great northern flow of ice, and break through it into the Atlantic, somewhere about the Orkney Islands—a most improbable thing indeed. The views advocated by Mr. Jamieson, in the *Quarterly Journal* (Vol. XXII., page 261), are those best borne out by the evidence, establishing a general glacial marine glaciation from the N.W. subsequent to the great flow of land ice from a north-eastern source. It is more in accordance with facts to suppose the shells found in the Caithness till to have come from a north-western direction than from the south-east; and the few shells discovered in the Kilmarnock till seem to indicate that this newer till, from the N.W. glaciation, may contain more evidence of marine fossils, in sections near the old sea level, than has hitherto been supposed.

[Since the above was written, Messrs. Kinahan and Close have published a paper on the "General Glaciation of Iar-Connaught, &c.," in which they account for cross striæ by the curving of the ice sheet, from divergence caused by mountain opposition.

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place assigned to it in the glaciation of the country, confusion will continue to exist.

Conclusion.—The evidence may be thus summed up:—That a sheet of ice, probably an extension of the circumpolar sheet, spread itself over these islands and the north of Europe, crossing valleys, and passing over hills nearly 2000 feet high. The source of this ice sheet was north-eastern, and the flow south-western. In its course it raised and broke up blocks of rock from the beds over which it passed, carrying them forward in the *moraine profonde*, or debris, that accumulated nnderneath it, only small patches of which exist at present in their normal state. 2nd, A melting or withdrawal of this ice sheet took place, and a land surface was exposed to at least 600 feet above the present sea-level, long enough to allow forest trees of no mean growth to exist, and the urus, elk, reindeer, mammoth, and even the horse to spread, as shown by the remains found at Cowden Glen, and Woodhill. 3rd, A second glaciation from a north-western direction ensued, caused by the submergence of the land, and the inflow of drift ice. The former deposits were nearly all removed, and a newer boulder clay, or till, laid down, formed from the older till, mixed up with rocks and debris from various distances, borne by the floating ice. Thus engraven upon the rocks are two sets of striæ from two distinct glaciations, divided from each other by a broad period of time; and to the second or north-western glaciation belongs the greater part of the boulder clays of central Scotland, with all the intercalated beds of sand, mud, and gravel.*

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* For discussion on this paper, see the "Proceedings," on a subsequent page.

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TABLE OF BOULDERS FOUND IN THE FOLLOWING SECTIONS.

NAME OF SECTION.	ERRATICS.		TRAPS.								CARBONIFEROUS.				NEW RED SANDSTONE.		AGE AND CHARACTER OF SECTION.
	Metamorphic.	Old Red Sandstone.	Porphyrite.	Amygdaloidal.	Tuffs.	Melaphyre.	Anamesite.	Dolerite.	Basalt.	Volcanic Ash.	Limestone.	Sandstone.	Ironstone.	Shale.			
Bonington, Kilmarnock,	1·6	1·44	14	...	7·50	17·42	8·33	28·29	2·21	2	4·71	10·54	2	...	·50	100	Upper bed, V.. N.W. glaciation.
Woodhill, ,,	1	·75	9·26	...	5·24	7·87	2·63	31	1	3·40	8	24·2	...	...	6·8	100	Upper bed, V.
North Woodhill, ,, No. 1*a*,	1·10	2·15	10·50	...	1·75	16·49	5	35·45	1·30	2	6·60	16	...	1·65	...	100	Lower bed, I.
,, ,, No. 2*a*,	2·50	15	15	...	2·50	...	7·50	20	30	...	...	5	2·50	...	...	100	Upper bed, V.
Greenhill Quarry ,, No. 1*a*,	4	3	11·43	...	...	11·72	5·65	30·77	...	...	...	33·43	...	...	...	100	Upper bed, VI.
,, ,, No. 2*a*,	2·14	...	10·21	...	2·53	12·97	2·73	30·81	...	2·93	12·76	12·83	7·46	2·63	...	100	Lower bed, I.
Towerhill, Kilmaurs,	3·66	1·74	21·48	...	·74	3·56	2·18	33·36	8·61	...	8·20	8	7·96	...	...	100	Doubtful.
Wheatrig, ,,	2·96	...	42·2	...	...	5·97	5·96	18·56	1·93	2·36	...	20·24	...	...	...	100	Sand and gravel.
Flowers, Stewarton, No. 1*a*,	6·6	7·7	35·36	3·3	...	6·6	7·7	17·17	...	2·2	5·5	11·11	...	...	...	100	Lower bed, upper surface.
,, ,, No. 2*a*,	4	3	41	1	...	10	5	7	...	5	12	12	...	...	...	100	,, ,, under surface.
,, ,, No. 3*a*,	3	1·20	34·6	·33	3·36	4·36	...	15·55	2·60	3	9·44	18	2·45	...	...	100	,, ,,
Horsemuir, ,,	7·26	4·19	30·13	...	...	...	...	34·50	1·60	4·49	1·60	15·93	...	...	...	100	Upper bed.
Peacockbank, ,,	5·91	4·25	26·75	·42	...	...	3·34	22	2	...	23·37	9·8	·42	2·46	...	100	Doubtful.
Netherton, Dunlop,	4·33	7·19	30·77	3·16	2·73	4·25	1·71	2·25	...	...	16·14	23·79	3·68	...	...	100	Lower bed.
Lochlibo, Neilston,	14·2	14·3	35·19	2·27	7·5	9·18	4	3·5	...	...	...	9·21	2	...	...	100	Sand mound.
Shelford, ,,	8·63	4·11	41·40	6·31	5·3	8·30	7·23	4·38	2·6	...	·60	10·35	4·9	...	...	100	Upper bed.
Nethertrees, Lochwinnoch,	12·13	11·30	29·34	2·5	2·6	6·47	7·17	4·5	10·30	...	3·42	8·15	3·3	·50	...	100	Mixture of both beds.
Bogside, Beith,	10·60	6·41	42·41	5·53	6·61	11·13	2·11	5·53	1·5	...	·40	4·33	3·24	...	...	100	Sand mound.
Langside, ,,	7·8	24·13	30·7	2·21	...	9·77	4	9·63	2·67	...	3·51	5·65	1·28	...	...	100	Upper bed.
Overtoun, ,,	12·4	6·2	13·18	...	5·5	4·2	15·17	18·23	...	...	...	5·9	2·2	9·18	...	100	,, ,,
Windyhouse, Beith, No. 1*a*,	...	11·13	11·13	...	...	33·33	...	11·13	...	...	...	15·49	...	27·79	...	100	Brick clay.
,, ,, No. 2*a*,	...	...	10·60	...	...	...	...	16·10	...	...	16·10	26·15	...	31·5	...	100	Upper patch.
,, ,, No. 3*a*,	...	5	12·49	...	·54	6·48	1·96	9·68	1·98	...	52·65	5·89	2·13	1·20	...	100	Lower bed.
Roughwood, ,, No. 1*a*,	3·93	...	14·16	...	3·38	14·78	22·45	22·44	...	...	...	14·87	3·65	...	...	100	Upper bed.
,, ,, No. 2*a*,	...	1·53	8·98	...	...	2·12	...	13·24	...	...	55·76	5·33	13·3	...	...	100	Lower bed.
Seedhills, Paisley,	9·71	24·5	5·13	...	...	·50	...	29·15	3·93	·73	17·95	5·12	2·44	...	...	100	Upper bed.
Garval Park, Greenock,	20·37	61·10	4·35	...	...	2·50	1·73	3·90	5·45	...	...	...	...	...	...	100	Doubtful.
Planetreeyetts,	16·86	4·37	56·54	13	...	8·70	...	...	...	...	...	...	...	...	...	100	Upper bed.

See p. 150.

NOTE.—There were a few rocks, of no specific character, found in all the sections that are not included in the Table. The nomenclature is that adopted by the Geological Survey, and none were admitted below three inches in diameter.

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APPENDIX.

TABLE OF PLACES WHERE DIRECTION OF STRIÆ HAVE BEEN OBSERVED.

(For additional Places, see present Vol., p. 56.)

Localities.	Direction.
Symington, near Kilmarnock,	N.E. by N. to S.W. by S.
Greenhill, near Kilmarnock,	N.E. to S.W.
North End of Stewarton,	E.N.E. to W.S.W.
Near Loudonhill,	N.E. by N. to S.W. by S.
Cleuch, near Fenwick,	N.E. by N. to S.W. by S.
Auchenmade, Kilwinning, older set,	N.E. by E. to S.W. by W.
Do., do., newer set,	N. by W. to S. by E.
Roughwood, Beith, older set,	N.E. to S.W.
Do., do., newer set,	N. by W. to S. by E.
Windyhouse, do., older set,	N.E. by N. to S.W. by W.
Cumnock, do., newer set,	NN.W. to SS.E.
Linn, Dalry, older set,	N.E. by N. to S.W. by S.
Crofthead, Neilston, older set,	E.N.E. to W.S.W.
Ardenhead, Busby, newer set,	N.W. by W. to S.E. by E.
Orchard, do., do.,	N.W. by N. to S.E. by S.
Giffnock, Shaws, do.,	N.W. to S.E.
Thorntonhall, Kilbride, older set,	E.N.E. to W.S.W.
Do., do., newer set,	N.W. by N. to S.E. by S.
Seedhills, Paisley, older set,	NN.E. to SS.W.
Do., do., newer set,	N.W. by W. to S.E. by E.
Planetreeyetts, Kilmalcolm, newer set,	N.W. by N. to S.E. by E.

The above direction of glacial striæ, taken (per compass) in 17 different sections, in all parts of the district, give a representation of the ice trend in the district under review. Other places could have been added, but as these are close to those given, it would only have enlarged the table without increasing the value of it. The section at Thorntonhall was rather obscure, the rock being scratched in all directions. But the directions given appeared to be the two general ones. The E.N.E. set were only seen faintly, in small patches, and at distances apart, apparently remains of the oldest set visible. Since the paper was read, another section of clay has been removed at Seedhills, to the south of the one described in the paper. This section is more obscure than the one described. The surface of the rock is more scratched and broken, and gives evidence of a heavy body striking and rebounding rather than of one passing quietly over it, as a sheet of ice is known to do. This roughness of the surface, and interruption in the striations and polish, is generally found accompanying the N.W. striæ, and is another evidence in support of submergence

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and bergs. Below the older till, the striæ are not interrupted in this manner, but go along without a break. In Roughwood I have observed them for hundreds of yards going along straight, as if done by a machine; and this is their general character.

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KILMARNOCK DISTRICT.

Hillhead, Kilmarnock.

	Ft.	In.	Ft.	In.
No. 1.				
Surface clay,	37	0		
Clay, mixed with coal,	2	0		
Coal,	0	10		
			39	10
No. 2.				
Surface clay,	56	6		
			56	6

Woodhill, Kilmaurs.

No. 1.				
Soil and clay,	24	0		
Soft muddy sand,	38	6		
Sand,	4	0		
Soft mud,	4	6		
			71	0
No. 2.				
Surface clay (sandy),	60	0		
Muddy sand,	9	0		
Gravel,	4	0		
			73	0
No. 3.				
Surface clay,	60	0		
Muddy sand,	7	0		
Stony clay,	7	0		
			74	0
No. 4.				
Clay and boulders,	36	6		
			36	6
No. 5.				
Surface clay,	26	10		
			26	10

Bonington, Kilmarnock.

Clay,	4	0		
Mud,	2	0		
Clay,	10	0		
Gravel,	1	0		
Clay,	29	0		
			46	0

South Woodhill.

No. 1.				
Surface till and stones,	37	0		
			37	0
No. 2.				
Surface till and stones,	50	0		
Mud and sand,	4	0		
			54	0

Milton, Galston.

	Ft.	In.	Ft.	In.
Gravel and sand,	5	0		
Sandy clay and stones,	6	4		
Gravel and sand,	5	0		
Clay and small stones,	33	3		
Sand and gravel,	6	0		
			55	7

Newmills.

Soil and sand,	6	6		
Muddy clay,	13	0		
Clay,	14	0		
Gravel,	25	0		
Brown clay,	7	6		
Sandy clay,	2	0		
Gravel,	3	0		
Till,	15	0		
			86	0

IRVINE DISTRICT.

Broomlands.

Surface,	3	0		
Sandstones,	6	0		
Mud,	16	0		
Clay and boulders,	14	0		
Sand,	2	0		
			41	0

Bogside.

Sand and gravel,	23	0		
Soft clay,	6	0		
Stony clay,	10	8		
			39	8
Sand,	31	0		
Gravel,	6	0		
Strong clay,	67	0		
			104	0

Fergushill.

Clay and boulders,	24	0		
Sand,	27	0		
Clay and boulders,	6	0		
			57	0

Roseholm.

Sand,	9	0		
Stony clay,	9	8		
Gravel,	13	6		
Stony clay,	15	0		
			47	2

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Eglinton.

	Ft.	In.	Ft.	In.
Clay,	5	0		
Sand and gravel,	7	6		
Clay and boulders,	24	0		
Gravel,	2	0		
Clay and boulders,	8	6		
Gravel,	2	6		
Sand,	2	6		
			52	0

Blair, Dalry.

Boulder clay,	24	0		
Gravel,	20	0		
			44	0

Courthill, Dalry.

Boulder clay,	108	0		
			108	0

Hinddog, Dalry.

Boulder clay,	48	0		
Gravel,	24	0		
			72	0

Mossend, Dalry.

Sand and mud,	20	0		
Boulder clay,	40	0		
			60	0

South End of Kilbirnie Loch.

Boulder clay,	40	0		
			40	0

Willowyard, Beith.
(East side of same Loch.)

Boulder clay,	80	0		
			80	0

NOTE.—A large number of journals of bores could be added to these, but the above give a fair idea of the glacial deposits in North Ayrshire. Except in a locality where open sections can be studied, bores are of little value to the geologist in deciding the character of a bed.

XII.—*On the* SILURIAN ROCKS *of the* SOUTH OF SCOTLAND. By CHARLES LAPWORTH, Galashiels.

(Read 25th January, 1872.)

THE author began by calling attention to the fact that the geological framework of Scotland is essentially composed of rocks of Silurian age, which occupy almost the whole of the northern and southern divisions of the country, and form in the centre a comparatively small synclinal hollow or basin, which is filled up by deposits belonging to the later systems of the Old Red Sandstone and Carboniferous. It thus becomes one of the first problems in Scottish Geology to ascertain the order of succession among these Silurian strata, to endeavour to read the history of its life system, and in general to obtain means for a comparison of the formation with the Silurian of other countries. To this problem the crystalline and metamorphic rocks of the Highlands can never

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furnish the key, which must therefore be sought among the comparatively unaltered and more fossiliferous deposits of the Southern Uplands. Here, however, we are at once brought face to face with what seem at first to be insurmountable difficulties. There is an almost complete identity of mineral character throughout the whole series; there are great thicknesses of strata from which fossils appear to be wholly absent; and, to crown all, the beds have been thrown into such a multitude of wrinkles and plications, so disturbed and inverted, that it is impossible to say on physical evidence alone, in a traverse of any distance, whether we are ascending or descending in the order of the strata. With these obstacles in the way of their thorough investigation, it becomes at once evident why so little, comparatively speaking, is known concerning them.

Nevertheless, a certain general arrangement of the strata may be said to be clearly ascertained. The lowest beds appear to form an axial or central mass of rocks, probably composed of strata of Cambrian and Lowest Silurian age, which dip N.W. and S.E. from an axial line running S.W. from Jedburgh to Kirkcudbright. To the north of these succeed a series of carbonaceous shales, of Llandeilo and Lower Caradoc age, which, together with an overlying mass of Upper Caradoc and Llandovery strata, undulate over the whole of the country lying between St. Abb's Head and the Mull of Galloway; while the district stretching from the central Cheviots to Kirkcudbright is composed of Upper Silurian strata, the northern equivalents of which pass up conformably into the Old Red Sandstone, in a few inliers that protrude through the Carboniferous of the Central Basin.

Mr. Lapworth then traced the history of discovery among these rocks, from the time of Dr. Hutton to the date of Professor Geikie's exhaustive paper on the whole subject, read before this Society in 1867. Since that paper was published the fossiliferous districts of Girvan and Wanlockhead have been mapped and described by the Geological Survey, the Pentland beds have been more fully investigated, and the rocks of the eastern districts, comprising the Gala Group, Riccarton Beds, Hawick Rocks, &c., have been examined and described by the author and his friend Mr. James Wilson.

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The several sub-divisions were next described, according to the following scheme:—

(*a*) *Lower Silurian.*	
(1.) Hawick and Selkirk Rocks, . .	Cambrian. Skiddaw, &c.
(2.) Moffat Shale or Anthracite.	
(*a*) Lower Anthracite, . .	Lower Llandeilo.
(*b*) Middle Anthracite, . .	Upper Llandeilo.
(*c*) Upper Anthracite, . .	Lower Caradoc.
(*b*) *Middle Silurian.*	
(1.) The Gala Group, Girvan Series, Duntercleuch Beds, Wrae Beds, &c.	Upper Caradoc. Lower Llandovery. Upper Llandovery.
(*c*) *Upper Silurian.*	
(1.) The Balmae and Riccarton Beds, .	Wenlock and Lower Ludlow.
(2.) Lower Pentland Beds, . . .	Wenlock.
(*b*) Upper Pentland Beds, .	Ludlow.
(*c*) Pentland Sandstone, . .	Passage Beds and Downton Sandstone.
(3.) Lesmahagow Beds, . . .	

(*a.*) Lower Silurian.

I.—Hawick and Selkirk Rocks.

The soft ripple-marked greywackes and sandy shales that make up the great group of the Hawick and Selkirk rocks bear a remarkable resemblance to the strata of the Longmynd, and it is not improbable that the lower beds may be of that age. The numerous instances of false bedding, the ripple and eddy markings, the rapid alternations of sand and mud, the worm burrows, the rain prints, &c., which abound in these strata, all point to the fact of their deposition in a shallow sea, the shores of which were laid bare at intervals to the rain and sun. These rocks appear to stretch uninterruptedly from the edge of the Old Red Sandstone, in the valley of the Lower Teviot, where they have a breadth of about fifteen miles, to the neighbourhood of Kirkcudbright, where they gradually die away to a point as they are overlapped by the Upper Silurian.

II.—The Moffat Shale.

Succeeding at once to the Selkirk rocks comes the remarkable deposit of the Moffat shale. It consists of a thickness of about 500 feet of finely-laminated white or grey mudstones, with beds

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or bands of carbonaceous shale, crammed with Graptolites. This mass of shale makes its appearance, again and again, throughout all the Silurian country that lies to the north of the Hawick and Selkirk rocks. This great tract may be considered in effect as a sheet of Llandeilo, Caradoc, and Llandovery strata, of no great thickness, which has been thrown into innumerable wrinkles and contortions. The folds, however, although often inverting the strata, appear never to have been of sufficient intensity to bring up the underlying Selkirk rocks; and it is very doubtful if the base of the Moffat shale is anywhere exposed among them.

With so many appearances of this Moffat shale, it would naturally be supposed that its relations to the neighbouring strata would easily be ascertained; but, unfortunately, whenever it comes to the surface, it is so crushed and crumpled, and so broken up by faults, that two entirely contrary opinions have been held regarding it. By Professor Harkness these shales are considered to be part of one and the same deposit, and to owe their present position to great faults that run along the strike of the beds. By others—and this opinion has been lately adopted by the Geological Survey—it is held that there are several of these bands, some of them separated from each other by thousands of feet of intervening strata.

The author assumed that he had proved that there was but a single mass of this shale, and of the thickness and character given above. This Anthracitic shale is separable, lithologically and paleontologically, into three portions, viz.:—(1.) *The Lower Anthracite*, of about 200 feet in thickness, and consisting of several distinct bands of mudstone and black shale; (2.) *The Middle Anthracite* (100 feet), consisting in its lower portion of black shale, in its upper part of green mudstones; (3.) *The Upper Anthracite* (150 feet), made up of a lower portion, consisting of black shale, and an upper portion (*Halli* beds), consisting of alternations of grey and black shales. Each of these great divisions contains many fossils peculiar to itself (see Appendix, p. 170), and each is separable into several stages or zones, characterized by the presence of some peculiar group of forms; and these zones are easily recognizable and hold the same inter-relations, in localities forty or fifty miles asunder. Middle and Upper Anthracites are unknown in the Moorfoot and Wanlockhead district, but the Lower Anthracite is present in all its sub-divisions.

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(*b.*) Middle Silurian.

The *Middle Silurians*, which were held to comprise all the strata which lie in the several troughs formed by the Moffat shale, were described in order as they range from east to west, under the several titles of the Gala Group, the calcareous beds of the Wrae Hill, Winkstone, and Duntercleuch, the Girvan Series, &c. Of these the Gala group and the Girvan beds were shown to represent the extreme types; those of Girvan having been apparently deposited in shallow water, and are remarkable for their massive conglomerates and limestones, which abound in fossil testacea. The Gala group was apparently the product of a deep sea, and yields few fossils beside Phyllopoda and Graptolites; while the beds which fill up the intermediate districts combine the characters of these two extremes, their calcareous strata furnishing the shells of the Girvan series, while their associated shales yield the fossils of the Gala group. The lower beds of this great formation consist of immense masses of grit and conglomerate, which attain their maximum development in the Girvan district, the included stones gradually decreasing in size as we proceed eastward. The proofs of the great extent of these deposits, their connection with those of Wales and Ireland, and the wonderful agreement of the various sets of fossils collected in the different localities, were pointed out, as well as the impossibility of subdividing the strata with our present knowledge.

(*c.*) Upper Silurian.

Rocks of Upper Silurian age have long been known to geologists in a single area to the south of the axial line; *i.e.*, on the shores of Kirkcudbright Bay. The lecturer has, however, lately traced these Upper Silurian strata through all the country lying between that locality and the centre of the Cheviot Hills, and their complete identity over the whole district is proved by the discovery everywhere of their distinctive fossils. It was shown that they correspond in age with the Wenlock and Lower Ludlow Beds of England, and that they are simply the northerly continuation of a mass of exactly the same character lately mapped by the Geological Survey of England in the counties of Cumberland and Northumberland. The Upper Silurian rocks, as exposed in the Pentland Hills, were next alluded to, where, as Messrs. Brown and

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Henderson have shown, not only are both the Wenlock and Ludlow formations represented, but it is very probable that the so-called Old Red Sandstone of that district will prove to be the equivalent of the Downton Sandstone of Siluria. After a brief glance at the *fauna* of the Leshmahagow beds, and pointing out the fact that in future these beds would have a greater interest to the geologist, as furnishing the only section in Scotland where there was an unequivocal passage of Silurian into the Old Red Sandstone, Mr. Lapworth concluded by observing that, "although much difficult work in the investigation of these ancient strata remains yet to be accomplished, the grand outlines of their history may now be said to be fairly sketched out. They appear to contain no representatives of those primordial limestones of Wales and Bohemia, with their quaint Trilobites and Lingulæ. In that primeval time, all here seems to have been inland lake or shallow sea. But when we reach the threshold of the Middle Silurian, all is life and animation. The peculiar Anthracite beds give evidence of a deep and tranquil sea which stretched over the South of Scotland, over Ireland, and probably over Central Europe, and North America also, swarming with millions of zoophytes, whose remains now afford the richest Graptolite *fauna* of the Silurian world. Even at this early stage, in the thinning out of the anthracites to the north and west, and the gradual coming in of limestone and conglomerates, we have evidence of the same general arrangement of land and water which prevailed in the succeeding epoch. We next get glimpses of an interval during which these anthracitic beds were in some places elevated into dry land, altered into flinty slate, and their broken fragments rounded by the running brooks or the waves of the shore, and spread out as a fine conglomerate on the ocean bed. As we reach the higher strata of the Middle Silurian, the proofs of the proximity of land gain form and distinctness, and we have clear evidence of a great sea which lashed the shores of an ancient Atlantis, far to the west of our present Scotland, from whose now vanished cliffs the iceberg floated with its load of boulders, dropping them in lesser and lesser quantities as it passed outward to the slowly deepening sea. Meanwhile, the testacea and zoophytes flourished in the waters below, the accumulated exuviæ of the shell-fish forming the limestones and calcareous sandstones of the west, which gradually thin out as they pass into the eastern depths, of which the Graptolite and Phyllopod seem to have been

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almost the only inhabitants. Next comes the great epoch of the Upper Silurian, and we pass on through the wonderfully uniform time of the Kirkcudbright series into the swarming seas of the Pentlands, and finally reach the period of the great lobster-like Crustaceans of Lesmahagow, which ushers in a second cycle of inland seas and shallow waters; and the next chapter of the history opens with the Old Red Sandstone."

APPENDIX.

LISTS OF THE FOSSILS OF THE VARIOUS SUBDIVISIONS OF THE SOUTH SCOTTISH SILURIANS.

NOTE.

THE following lists of fossils have been inserted here at the desire of the Council of the Society, and may collectively be taken as a rough index of our present knowledge of this Silurian Fauna. They have been abridged from more general tables, in the compilation of which the principal authorities consulted were:—

M'Coy's *Paleozoic Rocks and Fossils; Siluria;* the various papers by Sir R. I. Murchison, Professors Nicol, Harkness, and Geikie, Mr. J. C. Moore, Mr. Salter, &c., in the *Quarterly Journal of the Geological Society;* Dr. Bigsby's *Thesaurus Siluricus;* the works of Mr. Thomas Davidson; the papers of Messrs. Brown and Henderson, and Mr. Haswell, on the Pentland Hills; and the several memoirs and explanations published by H.M. Geological Survey. (C. L.)

(*a*) LOWER SILURIAN.

I.—FOSSILS OF THE HAWICK AND SELKIRK ROCKS.

Arenicolites didyma.
,, sp.
Palæochorda.
Protovirgularia.
Protichnites Scoticus.

FOSSILS OF THE MOFFAT SHALE.

II.—FORMS PECULIAR TO LOWER ANTHRACITE.

Cœnograpsus gracilis.
,, surcularis.
Thamnograpsus typus.
Rastrites Barrandii.
Didymograpsus sagittarius.
,, serratulus.
Dicranograpsus sextans.
,, furcatus.
Dicranograpsus formosus.
Dicellograpsus Moffatensis.
Climacograpsus bicornis.
Diplograpsus bimucronatus.
,, spinosus.
,, tricornis.
,, augustifolius.

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III.—Fossils Peculiar to the Middle Anthracite.

Cladograpsus linearis.
,, capillaris.
,, divaricatus.
Dicranograpsus ramosus.
,, Nicholsoni.
,, Clingani.
Dicellograpsus Morrisii.
Dicellograpsus elegans.
Climacograpsus teretiusculus.
Diplograpsus pristis.
,, mucronatus.
Lingula brevis.
Siphonotreta micula.
Acrotreta Nicholsoni.

IV.—Fossils which make their First Appearance in Upper Anthracite.

Diplograpsus vesiculosus.
,, cometa.
,, palmeus.
Monograpsus convolutus.
,, lobiferus.
Monograpsus sagittarius.
Rastrites peregrinus.
Peltocaris aptychoides.
,, Harknessi.
Discinocaris Browniana.

V.—Fossils which make their First Appearance in the Halli Beds.

Monograpsus Halli.
,, Nilssoni.
,, Sedgwickii.
,, turriculatus.
Rastrites Linnæi.
,, urceolus.
,, maximus.
Diplograpsus Hughesi.

(*b*) MIDDLE SILURIAN.

VI.—Fossils of the Gala Group.

Those marked "G" are also known in the Girvan Series.

Monograpsus priodon (G).
,, Sedgwickii (G).
,, convolutus (G).
,, Salteri (G).
,, turriculatus.
,, Nilssoni.
,, socialis.
,, colonus.
,, Halli.
Rastrites Linnæi.
,, maximus.
Cyrtograpsus Grayianus (G).
Retiolites obesus.
,, Geinitzianus (P).
Climacograpsus bullatus (G).
Dictyonema.
Protovirgularia.
Nereites Cambrensis.
Crossopodia Scotica.
Peltocaris.
Dictyocaris.
Ceratiocaris.
Orthoceras tenuicinctum (G).

VII.—Fossils Peculiar to Central Districts of Duntercleuch (1), Kilbucho (2), Wrae Hill (3), and Winkstone (4).

Petraia bina, 1, 2.
,, uniserialis, 1.
Glyptocrinus basilis, 1, 2, 4.
Trinucleus fimbriatus, 1.
Phacops Odini, 3.
,, Stokesii, 2.
Orthis protensa, 1.
Lingula ovata, 2, 4.
Porambonites intercedens, 3.
Spirifer plicatella, 1.
Raphistoma elliptica, 1.
,, lenticularis, 1.
Lituites cornuarietes, 3.
Cyloceras multicameratum, 3, 2.
Orthoceras ibex, 3.

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VIII.—Fossils Common to Girvan and the Central Districts.

Nidulites favus, 1.
Favosites fibrosa, 1, 2.
,, aspera, 1.
Petraia elongata, 1.
Ptilodictya dichotoma, 1.
Trinucleus concentricus, 1.
Phacops candatus, 1, 2.
Leptena sericea, 1.
,, tenuicincta, 1, 3.
,, transversalis, 1 (P).
Orthis calligramma, 1, 4.
,, elegantula, 1, 2 (P).
,, Actoniæ, 1, 2, 3.
Strophomena corrugata, 1.
,, pecten, 1 (P).
,, grandis, 1.
,, rhomboidalis, 1 (P).
Atrypa marginalis, 1.
,, hemispherica, 1.
Meristella augustifrons, 1.
Pentamerus oblongus, 1.
Bellerophon acutus, 1, 3.
,, trilobatus.
Orthis biforata, 3.
,, parva, 3.

IX.—Fossils of the Girvan Series.

The Letter "P" is placed opposite the Names of those Fossils which pass upwards into the Upper Silurian of the Pentland Hills.

Teutaculites Anglicus.
,, ornatus.
Stromatocerium rugosum.
Chœtetes Fletcheri (P).
Favosites crassa.
Halysites catenulatus.
Heliolites favosus.
,, interstinctus.
,, tubulosus.
,, inordinatus.
Petraia œquisulcata.
,, subduplicata (P).
Ptilodictya acuta.
,, costellata.
Acidaspis callipareos.
,, hystrix.
Asaphas gigas.
Bumastes Barriensis.
Bronteus Hibernicus.
Calymene Blumenbachii (P).
,, brevicapitata.
Cheirurus gelatinosus.
,, bimucronatus.
,, octolobatus.
Encrinurus punctatus.
,, sexcostatus.
Illenus Bowmanni.
,, nexilis.
,, Thomsoni.
Atrypa reticularis (P).
Chonetes lata.
Discina crassa.
,, perrugata.
Leptena alternata.
,, quinquecostata.
Acroculia haliotis.
Orthis reversa.
,, tricenaria.
Rhynconella œmula.
,, augustifrons.
,, cuncata.
,, borealis (P).
Strophomena filiosa.
Bellerophon bilobatus.
,, dilitatus (P).
,, falcatus.
,, carinatus (P).
Ecculiomphalus Bucklandi.
,, Scoticus.
Conularia Sowerbyi (P).
Maclurea Logani.
,, M'Coyi.
,, macromphala.
,, magna.
Theca reversa.
,, vaginula.
Conocardium dipterum.
Acroculia haliotis.

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Illenus latus.
Lichas laxatus.
Phacops Dalmanni.
,, Brogniarti.
Staurocephalus globiceps.
,, M'Lareni.
Trinucleus seticornis.
Beyrichia tuberculata.
Raphistoma striatula.
,, lenticularis.
,, equalis.
Cycloceras mulicameratum.
,, subarcuatum.
Holopella obsoleta (P).
Cyclonema crebristria.
Murchisonia augustata.
,, cancellatula.
,, pulchra.
,, simplex.
Ophileta compacta.
Pleurotomaria Moorei.
Orthoceros angulatum.
,, Barrandii.
,, bilineatum.
,, calamiteum.
,, politum.
,, vaginatum.

(c) UPPER SILURIAN.

X.—Fossils of the Upper Silurian Beds of Kirkcudbright, Dumfries, and Roxburgh.

Monograpsus Flemingii.
,, colonus.
,, priodon.
Peltocaris Wilsoni.
Ptilograpsus
Cyrtograpsus.
Ceratiocaris.
Pterygotus.
Phacops candatus.
Beyrichia tuberculata.
Leptena alternata.
Rhynconella nucula.
,, nasuta.
Leptena sericea.
Atrypa reticularis.
Chonetes sarcinatula.
Pterinea lineatula.
Orthonota decipiens.
,, inornata.
Bellerophon trilobatus.
Avicula lineata.

XI.—Fossils of Lower Pentland Beds.

Those Marked "L" pass Upwards into the succeeding Divisions.

Ptilodictya fucoides.
Ceriopora granulosa (L).
Chonetes lata.
Meristella tumida.
Strophomena Walmstedtii.
,, compressa.
,, applanata (L).
,, antiquata.
Orthis polygramma.
,, Lewisii.
,, biloba.
Rhynconella Wilsoni.
,, nucula.
Pentlandica (L).
Nucleospira pisum.
Athyris compressa.
Goniophora cymbæformis.
Ctenodonta obesa (L).
Cuculella antiqua (L).
Anodontopsis bulla (L).
Orthonota thracoides.
,, truncata.
,, impressa.
Mytilus mytilimeris.
Pterinea asperula.
Platyschisma simulans.
Euomphalus funatus (L).
,, sculptus (L.)
,, rugosus.
Phragmocras compressum.
Dictyocaris Ramsayi.
Entomis tuberosa (L).
Beyrichia Klœdeni (L).
Turrilepas Wrightii (L).

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XII.—Fossils of Upper Pentland Beds.

Chondrites verisimilis.
Favosiles alveolaris.
Protaster Sedgwickii.
Spirifer exporrecta.
,, crispa.
Crania implicata.
Discina rugata.
Lingula lata.
Pterinea retroflexa.
Bellerophon expansus.
Acroculia antiquata.
Orthoceras Maclareni.
,, gregarium.
Slimonia acuminata.
Cythere umbilicata.

XIII.—Fossils of the Lesmahagow Group.

Lingula cornea,
,, minima.
,, unguiculata.
Platyschisma simulans.
Ceratiocaris papilio.
,, stygius.
Physocaris vesica.
Dictyocaris Slimoni.
Pterygotus gigas.
Eurypterus obesus.
,, lanceolatus.
,, chartarius.
Himanopterus bilobus.
,, acuminatus.
,, perornatus.
Slimonia acuminata.
,, scorpoides.
Neolimulus falcatus.

XIII.—*On the* Origin of Petroleum.

By Richard Anderson, F.C.S., F.G.S., Uddingston.

Read 28th March, 1872.—(Abstract.)

In the opening of his paper, the author alluded to the different theories which had been propounded by geologists on the subject. There was, first, the distillation theory, that petroleum has been produced by the slow distillation, at low temperature, of coal and other bituminous substances within the earth. Next was the theory which supposed petroleum to have been produced from decayed vegetable matter by a process similar to that by which coal was formerly supposed to have been formed, viz., by the mineralisation of woody fibre which evolves marsh gas, carbonic acid, and water. The next notable theory was that petroleum in many cases must have been of animal origin, from the fact of its being found in the lower palæozoic strata, which contain no traces of land plants. Then there was Mr. Wall's "special mineralisation" theory, that bituminous matter has proceeded from vegetable remains which

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have undergone a special mineralisation, not attributable to heat, nor of the nature of a distillation, but due to chemical reaction at the ordinary temperature, and under normal conditions of climate. The author then proceeded to state some of the difficulties attaching to each of these theories as a solution of the problem of the origin of petroleum. These difficulties seemed to him too great for geologists themselves to clear away, and he believed it was only when geology was studied side by side with chemistry that anything like a satisfactory conclusion on the subject could be arrived at. The first difficulty which the geologist finds, on looking at it from his point of view, is that all petroleum could not have had the same origin. In Pennsylvania and Ohio the petroleum is found in the Devonian formation, while in Canada it is found in the Silurian limestone. In Europe and Asia it is found for the most part in the rocks of the newer secondary and Tertiary age. In Barbadoes, also, it occurs in Tertiary strata. The oil is very often found in fissures in the rocks. These fissures are more vertical than horizontal, and probably extend through many different strata. It has been noticed that the oil exists most plentifully in regions where the strata have been most disturbed, and where, as a consequence, the largest number of fissures occur. Another fact to be noted by geologists is, that in many cases there is no apparent reason to infer that petroleum has been derived from coal, inasmuch as it is found in districts far removed from the coal measures. The Canada oil is a notable instance of this, as, according to the distillation theory, it evidently proceeds from the lower seated Silurian and Devonian deposits. Again, one great objection to the distillation theory is, that when petroleum is found in the neighbourhood of bituminous coal, the coal itself does not appear to have lost any of its bituminous constituents. An instance is found at Ritchie County, Virginia, where strata have been elevated by an upthrow from several hundred feet below seams of cannel and bituminous coal, which appear to have lost none of their bituminous qualities. Professor Rogers also, in his description of the Appalachian coalfield, shows that the coal in that part of the region nearest the oil districts is far more bituminous than that which exists where no oil is found. With regard to the opinion that anthracite is the residuary coke remaining after the process of destructive distillation, it ought to be borne in mind that the fracture of anthracite is entirely different from the fracture of any bituminous coal. As to the theory of petroleum

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being derived from organic remains, the following remarks by Mr. Daddow, of Pottsville, he thought conclusively disposed of it:—"There is little probability that all the millions of mollusca entombed beneath the rocky crust of Venango would produce the flow of a single great well like the Noble, the Sherman, or the Philips. A shoal of whales (he adds) would not produce such astonishing results. That these ancient inhabitants of the sea should accumlate in certain localities to produce our present reservoirs of oil is not only improbable but impossible. Liberated oil or gas always rises to the surface of water, and this ancient life could only exist in water, and only be entombed beneath it, from whence the oil must have ascended to the surface almost immediately, as the result of pressure and heat; and it could never again sink, or exist beneath the water in the shape of oil or gas. This theory, therefore, could not be accepted as accounting for the existence or formation of petroleum." Finding so many weighty objections to the commonly received or purely geological theories of the origin of petroleum, the author said he had been led to inquire whether chemistry could throw any further light on the matter. It appeared to him that geology had done all that it could do, and that now the question had arrived at the point where chemistry alone could give any satisfactory explanation. In his inquiry he had found that a purely chemical theory had been offered to meet the difficulties of the case, and he would now endeaveur briefly to place it before them. The theory to which he referred had been advanced by the author he had already quoted, Mr. Samuel Harris Daddow, of Pottsville, who had worked it out with great care and fulness in his treatise on "Coal, Iron, and Oil," published in 1866. It is to the following effect:—Petroleum is essentially a compouud of carbon and hydrogen. The lighter kinds in their native condition consist of nearly equal parts of each of these elements. Under a high degree of heat, hydrogen unites with carbon, forming gas or oil; in fact, they seem to exist in combination naturally in a state of gas, which can be maintained only by heat or confinement. If liberated, they part readily in the temperature of summer. Thus we find the hydro-carbons in many forms, ranging from the lightest gas to a very solid substance. Petroleum is only a heavier oil, containing more carbon than naphtha, and less hydrogen, as we find exemplified in many oil wells. The oil found nearest the surface is always the thickest and most valuable; the second oils, found

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sometimes at a depth of 500 to 700 feet, are very light—less so when found at the depth of 200 or 300. The same oils in the great Kanawha valley, at a depth of 1500 feet, exist as gas or light naphtha. Now, the vapours escaping from smouldering volcanoes, if passed up through water, form oil by condensation, as many instances bear witness. It was easily conceivable, then, that during the formation of the rocky crust of the earth, the vapour of carbon which issued, as it still does in some degree, from the internal heat of the earth, did not escape entirely in vapour, but became condensed while rising through the thickening crust, in connection with hydrogen, forming hydro-carbon oils, which, in localities having the requisite conditions, became bituminous shales, asphaltum, &c. After the formation of coal in our great basins, the production of these gases diminished, and those produced became condensed before reaching the surface in the form of oil; while the continual contraction of the rocky crust of the earth by condensation in cooling, closed the fissures and sealed up much of the oil and gas in its deep cavities. The gases thus pent up would force themselves into and between the strata, wherever a lodgment could be found, and rise to the surface in the form of gas or oil through every crack or fissure that presented the means of escape. In this way the origin of petroleum could be accounted for, and the circumstances and conditions under which it is found by the borer at the present day explained. He would only add that this theory, so far as the condensation of carbon was concerned, was by no means unreasonable or impossible according to chemical laws. In the case of the making of steel, a similar process was seen to take place, by the charcoal imparting its carbon under heat to iron. And it was quite as reasonable to suppose that the vapours escaping from the smouldering internal fires of the earth, or from volcanoes, should unite with hydrogen as water or steam, and form those hydro-carbon products to which he had now called the attention of the society.

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XIV.—*On some* Recently-Exposed Sections *in the* Paisley Clay-beds, *and their* Relation *to the* Glacial Period.

By the Rev. William Fraser, LL.D., of Paisley, *Corresponding Member.*

Read 21st March, 1872.—(Abstract.)

After alluding to the progress which had been made of late years in the study of the glacial deposits, and to several important papers on the subject which had appeared in the Transactions of this Society, Dr. Fraser said he was persuaded that observers in this department were in the way of collecting data which would yet be of the greatest service in discussions as to geological time. He believed that a useful paper in that direction might be given, based on facts that had already been ascertained and classified. At present, however, he avoided these more important general questions, and confined himself to the statement of a few recent observations. The Paisley clays presented the following general order:—(1) Underlying all was the old boulder clay or till, the conditions of which were altogether unfavourable to life. It represented a cold, bleak, and in part tumultuary period. (2) Immediately above this was a laminated clay, whose texture was in every way distinct from the preceding. It was generally shell-less and stoneless, and in many instances beautifully and delicately laminated, the structure being at times so regular as to resemble the edge of a closed book, and specimens kept for a year or two had shown a texture and taken a polish like jasper. (3) Above the laminated clay, which was also useful in brickmaking, there occured a thick bed in which shells of arctic and boreal types were found—*Tellina proxima, Panopæa Norvegica, Pecten islandicus, Cyprina islandica,* and others too numerous to specify. Geologists loved the layer for its shells, while the brickfield proprietors regarded it with an intense dislike. (4) Next in order was the clay chiefly used in brickmaking. In it the glacial shells are not to be found; the last

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which disappears is the *Cyprina islandica*. But in these clays, indeed in all above the laminated clay, small and large stones, up to boulders of several tons in weight, were abundant. In some instances they bear longitudinal scratches, but they are deposited so irregularly that their lines lie in every direction; showing that while the origin of the lines or striæ may be ascribed to the period and the processes of the boulder clay, the transport and distribution of the materials were probably connected with subsequent movements, and especially with the melting of floating masses of ice. At the close of the formation of this clay series, and on its surface, appeared patches of a well-known shell, *Mytilus edulis*, the common mussel. (5) Terminating the series was a covering of varying thickness, and composed of various materials. There sometimes appeared near the surface a coarsely-laminated clay, which had occasionally been mistaken by observers for the more finely-laminated clay to be found at the commencement of the series. A long period, however, must have intervened between the two, and he suggested a careful scrutiny as to the phenomena connected with these two distinct clays.

Dr. Fraser then called attention to some facts which had recently come under his notice, showing, as he believed, that long after the period represented as glacial, and after the last of the clays had been deposited as the resting-place of the common mussel, there were, occasionally, in the valley of the Clyde, agencies at work which have since ceased to operate, at least to the same extent, in our now milder climate. It had been generally supposed that the rounded heights or knolls in the Clyde valley, where the rock was not immediately beneath the surface, were composed of boulder clay, and that when the surrounding masses were swept off and the valley was scooped out, the hollows had been left to be gradually filled with the later clays. In at least one instance this theory could be shown to be erroneous. Oakshaw Hill, on which part of Paisley is built, and on the crest of which the Neilson Institution rises with its dome, well known by many of our seaward travellers, was understood to be formed in this way. Its summit is about 106 feet above the sea level, and it stretches in a gradual slope for about 800 yards from west to east. When digging a foundation on the side of this hill or ridge for the Free Library and Museum which Sir Peter Coats had so generously granted to the town, a section was laid bare of what

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appeared to be the true till or boulder clay; but, very unexpectedly, underneath it was found the brick clay common to the Clyde district, with a bed of *Mytilus edulis* resting on its surface. The shells were in a perfect state of preservation, and he had dug into the clay to a depth of 4 or 5 feet, satisfying himself that it was identical with the brick clay now occupying the highest place in the Clyde series. This shell bed was 64 feet above the mean sea level, and the height rising over it was 42 feet of what in ordinary circumstances would have been accepted as genuine till or old boulder clay. The question which immediately suggested itself was, how came this superincumbent mass of clay—boulder clay apparently—to be placed there? It must have been at a comparatively recent time, and by gentle movements, for the mussels that lived there had been undisturbed. He thought it probable that, as the shell bed lay on the verge of a slope which passed into a hollow or valley, on the one side between Oakshaw and Castlehead, and on the other between Oakshaw and Woodside, and which had evidently been occupied by the sea to a considerable depth, masses of ice, carrying portions of the boulder clay, had been stranded on that ridge, and melting, had left what constituted the new height of very much the same material as that which was deposited by the great ice-sheet at an earlier stage of the glacial period. Dr. Fraser then traced a gradual descent in the mussel beds from the height of 64 feet referred to, down to similar beds in Glendaruel, Kyles of Bute. He had found one such bed under the late steeple at the Cross of Paisley, at a height of 40 feet above the sea level; another at the head of St. Mirren Street, at 32 feet; another in James' Street, at 23 feet; and another in Causeyside, at a height of only 12 feet; while out in the plain, and nearer the Clyde, he had found a fringe of shells, sea-weed, &c., which marked the tidal limit, subsequent, of course, to the time when the lowest of these beds was formed. Taking these facts into account, and assuming that Professor Geikie was correct in his inference of a certain elevation of the district since its occupation by the Romans, he thought they might be able to estimate approximately the length of time which had elapsed since the mussel beds were formed at a height of 64 feet above the present sea level. He concluded by submitting the opinion that intermediate between the isolated and incidental formation which he had described, and the primary boulder clay, there was evidence

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of what might be called a secondary boulder clay. He had been confirmed in this opinion by a careful examination of what seemed to be the old or primary boulder clay in Arran, in the valley between Lamlash and Slaodridh. When searching there for glacial shells, in that section specially described by Dr. Bryce in his excellent work on Arran, he had found two or three specimens of *Astarte borealis*, and a few fragments of others, in circumstances which rendered it improbable, he might say impossible, that they could have lived there. The texture and appearance of the clay led him to infer that it must have been formed during the glacial period, probably near its termination, but certainly long after the true or primary boulder clay had taken its place. He respectfully submitted these facts, in the hope that light might be thrown by other observers on points which were as yet confessedly difficult and obscure.

XV.—*On the* Valley *of* Loch Lomond. By G. H. Kinahan, M.R.I.A., &c., of the Geological Survey of the United Kingdom.

(Read 22nd February, 1872.)

Various theories have been advanced to account for the present features of the earth's surface. Formerly it seems to have been a very general belief that these features were all more or less due to movements in the crust of the earth, combined with marine denudation. Hutton seems to have been the first to broach the theory that the present surface was principally sculptured by meteoric abrasion. The senior geologists of the present day appear still to lay most stress upon former movements of the earth's crust; but, as a rule, the younger geologists may be divided into "Marinists" and "Subaerialists;" the latter class being, perhaps, at present the more numerous.

No one can deny that meteoric abrasion is capable of executing a vast amount of work, especially in tropical climates. In the temperate zones a third part, at least, of the earth's surface is enveloped by peat, timber, grass, or the like; consequently the work performed under these circumstances by meteoric abrasion is more limited, as no denudation can take place except on the

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bottoms or sides of ravines, river beds, and such places; while in Arctic and Alpine regions the effect of atmospheric denudation seems to be even less. It appears to me, therefore, that those who would account for the main features of the present surface, by such denudation, ascribe to it far greater results than it can fairly be held to have accomplished.

I still believe, for example, that many of the valleys in the south-west of Ireland, which the late Professor Jukes considered to be solely due to metoric abrasion, were in a great measure caused by breaks in the rocks, combined with marine action. In the promontories jutting out into the Atlantic, similar valleys are now being excavated by the sea along lines of breaks and faults. In the mining districts of the promontory of Crookhaven, all the valleys and surface fissures have been proved, by the underground workings, to occur along lines of breaks or faults ("slides" or "heaves" and "cross courses"), and I find the same facts in other places. All the valleys in the groups of hills called Slieve-Aughta and Slieve-Bernard (Clare and Galway) are connected with lines of faults. In the Kilkenny and Queen's County coalfield, the colliers have proved that most, if not all, the valleys in that upland are connected with breaks in the underlying rocks; while in West Galway, or Iar-Connaught (a country specially adapted for the study of its internal structure, as the surface-covering over large tracts is a thin coat of peat), I and my colleagues found that every valley, ravine, lake basin, or other feature, is more or less connected with faults and breaks in the rocks.

Scotland is intersected by systems of breaks, which, however, are more intricate, and not as regular as those in Ireland; apparently on account of their being so numerous, and of so many different ages, the newer deflecting and displacing the older.* In the Highlands of Scotland, as far as I have visited them (where the rocks are similar to those in West Galway), I did not meet with a valley, ravine, or lake basin unconnected with a break. And I believe, had time permitted, I could have proved systems of breaks both as old and as new as those in Iar-Connaught.†

Professor Ramsay, as is well known, has suggested that rock-

* One most conspicuous system in the South of Scotland extends into the north-east part of Ireland.

† Even in the coalfields in the neighbourhood of Edinburgh, I think it will be found that some of the faults displacing the coals are of corresponding age to some of those in the Irish coalfields, namely, post-glacial.

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basins containing lakes are due to the rocks having been eroded or scooped out by ice, seeing they are most numerous in those countries where signs of ice-action abound, whilst beyond the glaciated region they almost wholly cease. Sir Charles Lyell and others have urged several objections to this theory, and pointed out that it will not account for the formation of all lake rock-basins.

But if it be admitted that such basins are partly due to ice-action and partly to the contraction and displacement of the rocks, these objections would be removed; the hollows being at first formed by the crossing or junction of breaks, while subsequent ice-action would lift up and carry away all loose blocks and fragments to plane, scratch, polish, and etch the rocks *in situ;* and the longer the ice-stream lasted, so much less detritus would it contain to be deposited when it finally disappeared. This topic, however, would occupy too much time if now entered upon. Let us proceed to the special subject of this paper, namely, the formation of the valley of Loch Lomond.

The general bearing of the valley of Loch Lomond is north and south, corresponding with the lie of other important breaks in this part of Scotland. Extending from this valley eastward and westward are transverse features—some forming valleys, while others are marked by greater or less depressions in the hills. That all these valleys and depressions are connected with dislocations in the underlying strata is manifest by the strike of the rocks being deflected, or the beds of rock rising to the upthrow of the faults, or by the shifting of conspicuous beds of rock.

Loch Lomond, at no very remote period, must have been a fiord connected with the valley of the Clyde. This is proved by the raised beaches of the latter valley being on a similar horizon with the terraces in the Loch Lomond valley, and the gravel-bar across the latter, a little to the north of the lake. The lake-basin, therefore, at that time, was a submerged valley, which, prior to its submergence, if the theory of the Subaerialists be correct, was excavated by "rain and rivers" or ice.

The lake is divided into two portions by the chain of islands stretching westward from Balmaha. From the chart we learn that south of these islands it is shallow, rarely exceeding twelve fathoms in depth; however, in a few places it is thirteen, and in one spot, east of Inchmurrin, a hole fourteen fathoms deep is recorded. North of the islands the lake gradually deepens to

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Ross Point; it then shallows for a short distance, being only four or six fathoms deep on Hunter's Bank, which lies a little north-east of the inver of Douglas Water, but on the north of this bank it immediately deepens to over twenty-five fathoms, and northward it gradually gets deeper and deeper till it attains the maximum depth of 105 fathoms due west of the hamlet called Culness. North of this place a deep portion (over 100 fathoms) extends for nearly a mile, after which the basin gradually shallows to Whitepoint, between which and the end of the lake there is another deep portion, about 34 fathoms.

If we examine the country in the neighbourhood of the south part of the lake, we shall find there are features connected with breaks running about N. 30 E., the deeps in the adjoining portion of the lake basin having similar bearings. Immediately north of the islands the direction of the deeps is not so regular, being a combination of the N. 30 E., and a nearly N. and S. bearing, but in the rest of the lake they extend nearly north and south. Moreover, it may be observed that although the general bearing of the lake is N. and S., yet the deep portions in the north part have not an exactly similar lie, as in places they incline more or less to either side, from being deflected at the junctions of the transverse with the main valley. Furthermore, all the deepest spots coincide with one or other of these junctions.

The shallows may in part be due to accumulations when the lake was a fiord. It seems, however, that since it became fresh water they have considerably augmented by debris carried into them by the rivers and streams, especially the bank in the vicinity of the Douglas Water, which has all the character of a delta, shelving suddenly at its margin, especially northward.

The irregular deep, east of Ben Dhubh, occurs at the junction or crossing of different breaks. The sudden deepening north of Hunter's Bank seems, in part, due to a fault, a downthrow to the north, coming into the main valley from the east. The shallow to the south of the deepest spot is evidently on the N.W. side of the fault-line which is associated with the Tarbet valley. This appears to be a very recent fault, and has considerably shifted the main fault of the valley. The Inversnaid and Inverglass faults also slightly shift the main fault, while the deepest spot in the basin (105 fathoms) seems to be at the junction of the Main and Culness Valley faults. Having now stated the facts in connection with

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this lake-basin, we may consider suggestions as to its mode of formation.

If this valley were solely due to "rain and rivers," it would necessarily deepen gradually from its upper to its lower or south end. This, however, is not the case. If due to the erosion of ice, the deeps and shallows ought to graduate one into the other, and have a trend conformable with the lie of the valley, and consequently with the course of the glacier. This, however, is also contrary to facts. Again, marine action could not possibly have excavated this valley. On the contrary, it would tend to fill it up. Moreover, the extreme shallowness of the lower or south portion seems not to be due to such a cause, as the soundings record a rock bottom in many places.* Thus, "rain and rivers," ice, or marine action seems incapable, separately, of forming this basin, and we must look for causes elsewhere.

It has been shown that the valleys and depressions at the surface are connected with breaks in the strata, while the bearings of all the deeps in the lake-basin are similar to those of the features in the adjoining country, or they have a relation to the several junctions of the transverse valleys with the valley of Loch Lomond; consequently we have a right to assume that the form of the lake-basin is more or less connected with the breaks in the underlying strata. Let us suppose a great north and south break to have been first formed, with transverse breaks and their accompanying fissures branching from it. Meteoric abrasion, or marine action (if under the influence of the sea) would widen and deepen these; or if they were occupied by glaciers, all loose blocks and fragments of rock would be caught up and carried away, while the ice acting under the loosened blocks in the breaks, would lift them up and bring them under the transporting power of the glacier, especially in places where two or more breaks met or crossed, where it would excavate the rock to a great extent, thus forming deeps. Subsequently-formed breaks or dislocations would shift the work previously accomplished, and more or less modify it. By such a process, all the phenomena of this lake-basin may be accounted for—even the formation of the deep spot due west of the village of Culness.

For the excavating of this Culness deep, two theories may be suggested. Suppose the land to be 600 feet higher than at present,

* It should be pointed out that the principal deep is similarly situated to deeps in fiords, the charts of which have been examined.

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and "rain and rivers" to be the workers. This being at the junction of the Main and the Culness valley breaks, it is therefore possible that in this place there might have been a subterranean outlet, which was capable of draining the water out of the greater portion of the basin of Loch Lomond; and such subterranean outlets at the junction of two or more breaks are not uncommon among similar rocks in the hills of Iar-Connaught, Ireland, where the "fault-rock" is of an incoherent nature or open structure; or when an internal fissure has not been filled with minerals. Such a theory as this would necessitate that all the rock debris taken out of the valley—which may have been more or less in accordance with the size of the original fissures due to the shrinkage of the rocks—was carried away through the subterranean passage; and as I have previously shown when describing the subterranean drainage in the neighbourhood of Gort, County Galway,* a considerable amount of detritus, and even blocks of stones, may be carried away through such passages. This theory, however, I own, does not appear to be satisfactory. I would therefore suggest, that after the main line of the valley was laid out by a break in the underlying stata, marine action, meteoric abrasion and ice, separately and combined, performed their respective parts in modifying, widening, and deepening the valley. During this process, other dislocations occurred, which also helped to modify the original form of the valley; and subsequently, among the later movements of the surface, the lower portions of the lake may have been lifted higher than the northern part, or the upper portion may have been depressed beneath its former level. That some of the dislocations in connection with this valley are post-glacial I am strongly inclined to believe. My examination, however, was too brief and restricted to justify me in making a positive assertion on this point; but the features of the country about the north part of Loch Lomond, and also in the neighbourhood of Loch Katrine, seemed to indicate very recent movements and breaks in the underlying rocks.†

* Memoir, Geol. Sur., Ireland, Extract Sheets 115 and 116.

† Loughs Corrib, Mask, and Derg, in Ireland, resemble Loch Lomond in several of the aspects that have been described. The latter especially is most interesting; its main feature being a break with a bearing of about N. 30 E. This has been shifted four times eastward, by nearly E. and W. faults (N. 80 E.), all downthrows to the south, whilst each of these faults are connected with valleys or conspicuous features in the mountain group called Slieve-Aughta, which occupies the country to the west of the lake.

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It may naturally be asked why the basin of Loch Lomond was not more silted up during the period of its being a fiord; as the tidal action ought, as at the present day, to have spread the materials carried down by the streams more evenly over its bottom, filling up or modifying the deeps. In reply, I would suggest that at that time there was an arctic climate, as is proved by the fossils found in the raised beaches of the Clyde valley; and consequently the fiord was yearly covered with ice, or had an "ice-foot," on which was caught most of the debris brought down from the hills to be floated out to sea—little or none of it remaining to be deposited in the lake basin.

XVI.—*Notes on* Carboniferous Fossils. By James Thomson, F.G.S., *Vice-President.*

I. *On the* Plagiostomous Fishes *of the* Coal Measures, *particularly* Orthacanthus Dechenii (Goldfuss).

(Read 19th October, 1871.)

Professor Agassiz, in his *Poissons Fossiles*, published in 1837, described the genus *Diplodus* (sp. *gibbosus* and *minutus*) from specimens, chiefly of dissociated teeth, found in the English coal-fields. Subsequently, a well-preserved fish was discovered in Bohemia, and described in 1847 by Goldfuss, who named it *Orthacanthus Dechenii*. In 1848, Professor Beyrich, of Berlin, described the same fish, and named it *Xenacanthus Dechenii*, founding on the fact that the spine had a greater similarity to *Pleuracanthus* than to *Orthacanthus*.

At the meeting of the British Association in Glasgow, in 1855, Sir Philip Egerton, from discoveries that had been made in the interval, pointed out that the spines of *Pleuracanthus* and the teeth of *Diplodus* belonged, in fact, to the same fish. The specimens from which Sir Philip proved this to the Association were obtained from Carluke and Edinburgh.

In 1867 Professor Kner went carefully over the remains of such fishes in the museums of Dresden, Berlin, Breslau, and Vienna. Although none of the specimens found in these museums were complete, yet in some of them he found the teeth of *Diplodus*

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minutus of Agassiz in position, and from the external aspect of the fossils he accepted Goldfuss's generic name *Orthacanthus Dechenii.*

The specimen which the author now exhibited had been for many years in his collection, and had been provisionally named *Pleuracanthus minutus.* After a careful examination, however, of the microscopic structure both of the teeth and the shagreen, he could find no relation between the structure of *Pleuracanthus* and that now exhibited. In the meantime he accepted Professor Kner's identification, but thought it possible that the discovery of better preserved specimens would show that the difference of structural character might be due to difference of sex, as he had found to be the case in the recent Rays.

[Jaws of *Raia clavata*, both male and female, with the teeth in position, were exhibited in support of this view; and the paper was further illustrated by a number of microscopic sections of the teeth and other parts of the fishes referred to.]

II. *On* Carboniferous Hydrozoa *and* Echinoidea.

(Read 11th January, 1872.)

(1). *On Palæocoryne Scoticum and P. radiatum from the Carboniferous Shales of the West of Scotland.*—The author stated that at the first excursion of the Society to Corrieburn, in 1858, he had observed in some portions of shale a small, delicate, stellate body which he could not refer to any genus or species he had seen described. Since then, at various Saturday afternoon excursions of the Society, he had discovered other forms of a similar kind. He had consulted the collections of the Geological Society, the Government Museum of Practical Geology, and the British Museum in London, without finding any similar organisms; and, lacking the necessary facilities for prosecuting the work himself, he had at length placed them in the hands of Professor Duncan, in order that they might be identified and named. On investigation, Professor Duncan found them to be new and undescribed forms, which could only be referred to the *Hydrozoa.* With the exception of the *Oldhamia* of the Cambrian rocks of Ireland, supposed to belong to this order, and the impression of a *Medusa* said to have been observed by Professor Agassiz in the fine oolite slate of Solenhofen, these were the only fossil remains of *Hydrozoa* known. The calcareous investments of these *Palæocorynida* made their recognition

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as true *Hydrozoa* a matter of some difficulty; but this had been overcome by the examination of the anomalous genus *Bimeria* (Wright), which, as pointed out by Professor Duncan, shows a very decided resemblance to the fossil under consideration, the semi-solid investment being continued over the greater part of the tentacles and upper part of the body. These minute but interesting forms are found both in our highest and lowest beds of limestone—at Roughwood, Broadstone, Auchinskeigh, and Gare—and their discovery may be said to add another link to the chain that unites the present with the remote past.

(2). *On a Species of Palæchinus.*—At a recent visit of the Society to Auchinskeigh, he had observed on a slab of limestone shale numerous small plates of an *Echinoderm*, which he had not formerly met with. He was led to their identification generically by a manuscript of their late highly esteemed President, Dr. Scouler, who gave the above name to specimens which he had examined belonging to the Royal Dublin Society and the Rev. Mr. Fox. After consulting Dr. Scouler's description, and also Professor M'Coy's "Synopsis of the Carboniferous Fossils of Ireland," he (Mr. Thomson) could not refer the form now submitted to any of the species therein described. It was most nearly allied to Dr. Scouler's *P. sphæricus*, but it differed alike in the form and ornamentation of both the ambulacral and interambulacral plates. He proposed to name it provisionally *Palæchinus Scoticus*.

[The fossils and some beautiful microscopic sections were shown in illustration of this paper.]

III. *On an Undescribed* PLATYCRINUS *from the* MOUNTAIN LIMESTONE *of* FIFESHIRE.

(Read 2nd May, 1872.)

During a recent visit to the East Coast he had found the fossil referred to in a quarry to the west of Kirkcaldy. It was the head or "test" of a crinoid belonging to the genus *Platycrinus*. It is roughly spheroidal in outline. The inferior plate is hexagonal, the middle plates are pentagonal, and the upper extremity is made up of a series of irregularly formed plates. It differs in several respects from M'Coy's *Platycrinus punctatus*. The plates of the test of that author's form are punctate; while those of the form exhibited are smooth and destitute of surface ornamentation. It also differs in the form of the plates. Associated with the fossil

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were numerous fragments of the stems and arms of crinoids; but as none of these parts were found attached, he could not identify them as belonging to the test exhibited.

[The author was requested to prepare figures of the organisms referred to in the foregeing notes, and agreed to do so; but they have been delayed in the hope of his being able to reproduce exact representations of their delicate structure, by means of the new process by which he is figuring the Carboniferous Corals.]

XVII.—*Note on the* PITCHSTONE *at* CORRIEGILLS, ARRAN.

By DUGALD BELL, *Secretary.*

(Read 14th December, 1871.)

MR. RAMSAY, in his well-known little work on the Geology of Arran, published just thirty years ago, referring to "the largest and most important of all the pitchstone veins" on the eastern side of the island—that which occurs on the Corriegills shore—contented himself (contrary to his usual practice) with quoting Dr. Macculloch's "minute description" of it, which is as follows:—"It resembles so strongly a mass of prismatic trap, as to be often overlooked in walking along the shore, even by those who have been directed to the spot. From its horizontal position, it has been by some called a bed; but, like traps in similar cases, it may with propriety be considered a horizontal vein. The visible face is rudely prismatic, and about 12 feet thick, extending for about 200 yards, and terminating abruptly at each end. It is apparently conformable to the sandstone on which it lies; but whether rigidly so, cannot be discovered, as the faces of the cliffs are obscured, both by the mouldering of the rocks, and by dispersed patches of vegetation. Like the sandstone, it reclines to the south-west at an angle of about 30 degrees. Its texture is tolerably uniform throughout, being most commonly also lamellar, and it is of a dark or bottle-green colour. It is not accompanied by any visible disturbance of the adjoining sandstone, nor is there any apparent change in either rock at the places of contact; except that, as happens so frequently among the trap rocks, the vein decomposes to a certain depth near the junction."

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It is to the error in the last sentence I wish to call attention. Dr. Bryce, in his "Geology of Arran, &c." (latest edition), virtually repeats it. "There is no remarkable change," he says, "on the sandstone—a slight induration merely—but the lower portion of the pitchstone is changed into a blue-coloured, porous, slag-like matter, like a pumiceous lava: this, however, is probably the mere result of decomposition. Its exact position among the sandstone strata," adds Dr. Bryce, "is not easily determined; but there is little doubt that it intersects the beds, and is therefore an intrusive vein."

Having had an opportunity during last summer of examining this vein with some degree of care, I found that the alteration in the sandstone, though not extending far, is nevertheless quite distinct—the soft reddish rock being blackened, and rendered hard and splintery, with a dull, glossy fracture, like quartzite; and that this is observable on both the lower and upper sides of the vein, but perhaps chiefly on the lower. The intrusive character of the vein is thus clearly established. Further, the pitchstone assumes the bluish slaggy appearance described by Dr. Bryce, on *both* sides of the vein. The two rocks are thus much altered along both lines of contact. And the alteration in the pitchstone is something entirely different from the result of decomposition or weathering. It is an essential change in the structure of the rock; and we find nothing of the same sort taking place either on the exposed face of the vein, or in the innumerable fragments of it of all sizes, which are strewed on the hillside and along the shore. I conclude that there is every appearance of the action of great heat along the edges of this vein, which is thus no exception to the multitude of trap-dykes of various kinds which intersect this part of the Arran coast. Some of these dykes, it is to be observed, produce a much greater effect than others, as regards the extent to which the rock on either side is altered; sometimes a comparatively small dyke or vein has produced apparently a much greater effect than a larger one. These varieties may be due partly to differences in the traps themselves, some conveying more heat, or retaining it longer than others; and partly to differences in the contiguous rock, in its heat-conducting qualities, according as it is fine-grained or coarse, compact or porous, uniform or variable in structure.

[Specimens of the pitchstone, and of the sandstone in which it occurs, taken from both the upper and under sides of the vein,

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were submitted, showing the alteration in both rocks. Fragments of the pitchstone found on the hillside and along the shore, and portions of boulders crusted over with lichens, were also exhibited, shewing that the rock does not change by decomposition or weathering into anything like the porous, slaggy material which forms the sides of the vein.]

Postscript.—If errors such as that noticed above are repeated by our own writers, we need not wonder that they should find their way into the works of foreign authors. While this sheet is passing through the press, I observe an article in this month's number of the *Geological Magazine*, by Mr. S. Allport, F.G.S., who has examined with much care the microscopic structure of the igneous rocks of Arran, and brought out some very curious and interesting results. In this, his second paper on the subject, Mr. Allport writes :—

"In my former paper I described the pitchstones on the east and west coasts as occurring in intrusive veins and dykes, and subsequent examination has not only confirmed this view, but has also shown that the sandstones are greatly altered along the line of junction. Prof. Zirkel, on the other hand, states that the vein on the Corriegills shore has not produced the slightest change on the sandstones, and that it is regularly interbedded with them.—(Zeits. d. d. Geol., Ges. xxiii., p. 1.) It became necessary, therefore, to make another careful examination of the locality. The result was that the sandstone in contact with, or in close proximity to the pitchstone, is greatly indurated in places, while in others it is comparatively soft; but in these instances there is invariably an escape of water at the junction of the two rocks, and a partial disintegration has been the result. An examination, therefore, of such places only, might easily mislead an observer. As regards the relative positions of the two rocks, I have nothing to add to the previous account. In all the localities examined the pitchstone is clearly intrusive."—*Geol. Mag.*, Vol. IX., p. 536.

The observations I ventured to lay before the Society are thus fully confirmed.

Another addition I may make to this note. Dr. Bryce has correctly described the two large veins of pitchstone which appear high on the hillside between Dunfion and Dundhu, as also the continuation of the upper vein seen behind Dunfion. Neither of these, he points out, can have any connection with those seen on the shore in front. But there is an outcrop of pitchstone a little further west, at a lower level than these two, in the field behind South Corriegills farm-house, which may be a continuation of the shore, or Corriegills vein, that has been referred to. I have not traced it further west.

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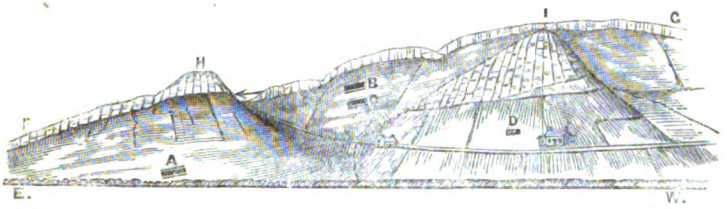
By the way, Dr. Bryce makes a mistake as to the relative heights of the two prominent hills of the Corriegills shore—Dunfion and Dundhu—which may as well be corrected. Dundhu, he states, is "nearly as high" as Dunfion,* while in fact it is the higher of the two by almost one-half—the heights being, Dunfion about 500, and Dundhu 700 feet.

Subjoined is a rough sketch of the locality.

December, 1872.



A. The Corriegills pitchstone vein. B, C, The two higher veins. Continuation of the upper vein behind Dunfion, indicated by the arrow. D, Portion of vein seen near South Corriegills (supposed continuation of shore vein A). F, G, Trappean ridge, extending from Clachland Point towards Lamlash Road; Dunfion (H) forming part of same; Dundhu (I)—of clay-stone porphyry—rising a little in front, with a hollow between.

* Geol of Arran, &c., p. 80.

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XVIII.—*Biographical Notice of the late* JOHN SCOULER, *M.D., LL.D., F.L.S., some time President of the Society.*

By WILLIAM KEDDIE, *F.R.S.E., Secretary to the Philosophical Society of Glasgow.*

DR. SCOULER was born in Glasgow, on the 31st of December, 1804. His early days were spent in the neighbourhood of Kilbarchan, where his father was a calico-printer, and there he received the rudiments of his education. While still at an early age, he entered the University of Glasgow; and, after passing through the literary and philosophical classes, devoted himself to the study of medicine. It was while attending the class of Botany, when the chair of that science was occupied by Dr. (afterwards Sir William) Hooker, and the Botanic Garden of Glasgow was constantly enriched by the introduction of new and exotic plants, which were duly delineated by the accomplished Professor, in the elegant pages of *Curtis's Magazine*, that Scouler first gave indication of the bent of his mind towards natural history. Dr. Hooker was not slow to discover and direct the tendency of his youthful pupil, whom he at once marked as being qualified for carrying on original research. In the meantime, Scouler, having completed his medical curriculum in Glasgow, repaired to Paris, where, in the unrivalled collections at the Jardin des Plantes, he enjoyed ample opportunities of extending his knowledge of Comparative Anatomy. A grateful recollection of his obligations to the Museum of Natural History in Paris induced him, at the close of life, to bequeath his ethnological collection to that institution. On his return from France he was, through the influence of Dr. Hooker, appointed surgeon and naturalist to the Hudson's Bay Company's ship "William and Ann," destined for the entrance of the Columbia River, in the year 1824. The same vessel conveyed Mr. David Douglas, an intelligent and enterprising young botanist, formerly assistant to Mr. Stewart Murray, curator of the Glasgow Botanic Garden, and who had already distinguished himself as a botanical collector to the Horticultural Society of London.

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In a paper on American Botany, in the *Edinburgh Journal of Science*, Dr. Hooker, after noticing with warm approval the appointment of Douglas, who amply justified the confidence which had been reposed in him, remarked:—"The Hudson's Bay Company, with a liberality that reflects the highest credit upon them, made application and provision for a surgeon to one of their ships, who, to his medical knowledge, should have added the acquirement of natural history, particularly of botany. It was our good fortune to have in view, at the period when the application was made, a young man every way qualified for such a situation, Mr. Scouler, unquestionably one of our ablest botanical students." Scouler and Douglas were men of kindred tastes and pursuits. They were alike affectionately attached to their patron, and the two became fast friends and zealous fellow-workers. In Douglas's account of the voyage, and other papers, published twelve years afterwards, we find him congratulating himself on his good fortune "in having a companion in Dr. Scouler, of Glasgow, a man skilled in several, and devotedly attached to all, branches of natural history." Dr. Scouler also wrote an account of the voyage, which appeared in the *Edinburgh Journal of Science* in 1827. A few particulars, culled from both sources, of an expedition which opened the career of two eminent scientific explorers, who have left their mark on natural history, will not be unacceptable to the reader.

The vessel sailed from London on the 25th of July, 1824. On touching at Madeira, the two naturalists made their first excursion on land, and collected numerous plants and insects, although the results scarcely satisfied their over-sanguine expectations. On resuming their voyage, they occupied themselves in the capture and examination of sea-birds, zoophytes, and mollusca, the latter including the *Pyrosoma*, belonging to a family of the class Tunicata, and consisting of species which are compound aggregate animals united organically, and are only found within very restricted oceanic limits. At Rio de Janeiro the shores abounded with Radiata; and our botanists here for the first time experienced the "intense curiosity" with which "one newly arrived from Europe visits the woods of a tropical country, and sees growing in their native wildness those plants which are cultivated with so much trouble and expense in more northern regions." Granite is the principal rock in the neighbourhood of Rio, and the large size of the crystals of felspar is noticed as peculiar. Ascending the

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Corcovado, a hill in the vicinity, celebrated for its commanding prospects, the naturalists expatiated amidst brilliant insects in endless variety, serpents and lizards, toucans, humming birds, and parrots, cooling streams and gentle cascades. The picture given by Scouler is charming, notwithstanding the prominence of the ophidian element:—"Serpents issuing from their holes in quest of their prey," together with the alert movements of lizards similarly occupied, exhibited "an appearance of life and activity that cannot fail to please." Slaves employed on the hill aided him in collecting insects, and one of them brought him "a fine living specimen of a beautiful snake, *Coluber venustissimus*." On the 13th October they took their departure from Rio, and early in November doubled Cape Horn. The tropic bird, the man-of-war bird, and other denizens of the torrid zone, were now replaced by the petrels and albatrosses of the southern hemisphere. Two hundred specimens of the Cape petrel *(Procellaria Capensis)* were caught off the Patagonian coast by means of a baited fish-hook; and in a single hour, forty specimens of the dark-coloured variety of albatross, some of them measuring seven feet between the tips of the wings, although the average weight of the bird was only about five pounds. A landing was made at Juan Fernandez, which is described as the Madeira of the southern hemisphere. The seamen regarded the island as classic ground, and the naturalists expected many additions to their collections in a territory as yet untrodden by the botanist. The flora was varied and luxuriant, ferns being particularly abundant, and the scenery of the island exceeded in beauty the anticipations of the visitors.

The ship next took the Galapagos on its route, and our two voyagers landed on James's Island, treading for the first time on volcanic ground, the loose lava reminding them of the slag and melted matter cast out of a smelting furnace. The shores yielded abundance of turtles, tortoises, iguanas, pelicans, and fish. Scouler kept one of the tortoises for eight months, during which time it did not consume above an ounce of food. In lat. 43 N.E., they found the sea covered with extensive fleets of the *Velella*, belonging to a family of Acalephs, having on the upper surface of the membranous body a vertical crest, the action of which has been compared to that of a lateen sail. These curious little ships were observed to extend in every direction, "a circumstance (Dr. Scouler remarked) which did not occur during any other period of

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our voyage; and the obstinacy with which these little animals continue in the same situation is well illustrated by the fact that they were seen by Capt. Vancouver in the same latitude more than thirty years since." On reaching the latitude of the Columbia River, such was the boisterous state of the weather that the vessel had to beat about for six weeks before a landing could be effected at Cape Disappointment, where Dr. Scouler and Mr. Douglas at length obtained a footing, on the 8th of April, 1825, after a voyage of eight months and fourteen days.

With eager joy and expectation the two naturalists began their work in the destined field of their explorations. "Next morning (says Douglas), Dr. Scouler and I went ashore on Cape Disappointment. On stepping out of the boat, we picked up *Rubus spectabilis* and *Gualtheria Shallon*, with several other plants which had only been known to us in the herbaria or by name. In a few hours we returned to the ship amply gratified." The second plant named had been discovered by Menzies growing in pine forests on the north-west coast, in conditions where scarcely any other plant could exist. Before taking his departure from London, Dr. Scouler had received much useful information respecting the country from Menzies, and he mentions that it was through the advice of that gentleman that he had been induced to pay particular attention to the seeds of *Gualtheria Shallon*. In *Curtis's Botanical Magazine* for 1828, a beautiful figure of the plant appeared, with a description by Sir William Hooker, who says, "It was not till last year that we had any prospect of cultivating so great a rarity, when seeds arrived both for the Horticultural Society of London and for the Glasgow Botanic Garden, gathered at the Columbia by Dr. Scouler and Mr. Douglas. These soon vegetated," &c. "The berries (it is added) of the *Shallon* are much esteemed by the natives, and we can attest their excellence from having tasted some which Dr. Scouler brought home."

On the second day the voyagers had their first sight of the natives, who presented a singular aspect, with their flat heads and high cheek-bones, many of their children still having their heads bandaged with the boards which, by constant pressure upon the skull from infancy, give it the permanent form characteristic of the fashionable Indian families in this region. The naturalists made a voyage together up the river as far as Fort Vancouver, 80 miles from the sea, studying the flora and fauna of the banks, and

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observing the habits of the natives, who at that time were very numerous, and subsisted almost entirely by fishing, without ever tilling the ground. Botanising in the fertile prairie around Fort Vancouver, they found an extensive tract covered with the blue flowers of *Phalangium esculentum*, a plant resembling our common field hyacinth, and affording to the natives a favourite article of food. Here also they met with the humble and graceful *Linnæa borealis*, well known from its occurrence in fir-woods in the north of Scotland and throughout the northern parts of Europe. After this excursion, Douglas made a journey into the interior, as far as the falls of the Columbia; while Scouler proceeded in the ship to the northward, visiting Queen Charlotte's Island and Observatory Inlet. The Indians here spoke a different language from that of the Columbian tribes. The practice of flattening the heads of children was unknown amongst them; but it was replaced by another, noticed by the early navigators, and scarcely less odious, but confined wholly to the female sex—that of making a large incision in the lower lip for the reception of an oval piece of wood, thus worn for ornament. The expedition, before returning to the Columbia, visited Nootka and De Fuca's Straits; but Scouler was prevented by the suspicious character of the natives from spending much time on shore. The natives of the Straits of De Fuca and the Gulf of Georgia resembled those of Nootka and the Columbia, both in respect of their language and in the custom of flattening the heads of their children. On returning to the Columbia, Scouler rejoined his companion Douglas, who had accomplished an arduous but successful journey to the falls of the river, at a distance of 250 miles from the coast. The two naturalists soon after separated, never to meet again. Douglas proceeded overland to the east coast of America, and taking ship at Hudson's Bay, sailed for England, where he arrived in October, 1827, laden with the trophies of his laborious journeys. Amongst the numerous plants introduced into this country as the fruits of his voyage to the Columbia, one of the best known and most widely disseminated is *Ribes sanguineum*. Of thirteen species of the genus *Pentstemon* he dedicated one to his friend Scouler. Douglas undertook a new mission to the Columbia River, for which he sailed in October, 1829, arriving at his destination in June, 1830. Two years afterwards we find him sending home to Scouler a tolerable collection of bones of "a sea otter, of wolves, foxes, deer,

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panthers," &c. "You may tell him," he says, writing to Sir W. Hooker, "that human heads are now plentiful in the Columbia, a dreadful intermittent fever having depopulated the neighbourhood of the river; not twelve grown-up persons remain of those whom we saw when he and I were together in 1825." Sir William adds, "Mr. Douglas here refers to Dr. Scouler's having carried away from the Columbia River the preserved skulls of two Chenooks, on account of the singular mode in which, by compressing the frontal bone in infancy, the heads of these people are made to assume a conical, almost sugar-loaf appearance. The indignation of the natives was much roused on this occasion, and Dr. Scouler would probably have met with very rough treatment if he had not deferred this robbery for the sake of science to the very night previous to the vessel sailing from the Columbia River, by which he was carried out of the reach of their resentment."*

During the remainder of Scouler's residence upon the north-west coast of America, his botanical and geological researches were diversified by observations on the languages, manners, and customs of the Indians. He made a collection of their fishing and other implements, domestic utensils, dresses, arms, and skulls, to which a furtive raid upon one of the curious native places of sepulture enabled him to add the mummy of a child, with an artificially-flattened head, the abstraction of which from its appropriate canoe caused much irritation amongst the natives, who were accustomed to show great respect for their dead. This ethnological collection, which was for many years an object of attraction in the Andersonian Museum, Glasgow, was, as we have already mentioned, bequeathed by Dr. Scouler at his death to the Museum of Natural History in Paris. His "Observations on the Indigenous Tribes of the North-West Coast of America" were published in the *London Geographical Journal*, and contained an extensive series of vocabularies of Indian languages. To the *Zoological Magazine* he contributed a separate paper, in which he classified the various tribes found from Behring's Straits to the Columbia River, and included between the Rocky Mountains and the Pacific Ocean.

* From the north-west coast of America, where fresh discoveries had rewarded his enterprise, Douglas proceeded to the Sandwich Islands, in 1833. Next year, when at Hawaii, the career of this intrepid naturalist and amiable man was suddenly arrested. He accidentally fell into a trap dug for the capture of wild bullocks, and was trampled to death.

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In dedicating a new genus of Mosses to Dr. Scouler, Sir W. Hooker says:—"It gives me great pleasure, in looking over the valuable botanical collection made by Dr. Scouler on the north-west coast of America, to find a plant (gathered in running streams at Observatory Inlet) belonging to his favourite tribe, the *Musci*, which, constituting a new genus, I am thus able to dedicate to him" (*Scouleria aquatica*). Reverting to his success as a botanical student in former years, Sir William adds:—"Although the anatomy and physiology of animals be his most favourite pursuit, and the one by which it is to be expected that he will, at a future time, rise to much fame, yet botany has occupied a great share of his attention, and his herbarium includes much of novelty from the countries which, like a second Menzies, he has visited, and, as a naturalist, successfully investigated."

Soon after his return from America, with his rich collections in all the departments of Natural History, Dr. Scouler, with the view of enlarging his knowledge, engaged himself as surgeon to a merchant vessel named "The Clyde," bound for Calcutta, and touching also at the Cape of Good Hope and Madras. Of this voyage we have met with no record. On his return to Glasgow he settled down to the practice of medicine; but in a short time a more congenial sphere of labour, although a less lucrative one, was opened up to him by his being appointed Professor of Natural History in the Andersonian University. Here he spent several of his happiest years in teaching, in collecting geological specimens, and in arranging the materials which were contributed from all quarters for the formation of a Museum of Natural History. From this period his attention became, in a great measure, withdrawn from botanical pursuits, and, as his early preceptor had anticipated, he devoted himself principally to the study of zoology and geology. At the same time he lost no opportunity of adding to his knowledge of modern languages, and of enlarging his collection of works in foreign literature. During this period, also, he was associated with two of his medical colleagues in establishing the *Glasgow Medical Journal*, and in 1831 we find his name in Cheek's *Edinburgh Journal* as one of the editors of that work, which was devoted to natural and geographical science. The number for June, in the year mentioned, announces the discontinuance of the summer course of lectures on Comparative Anatomy in the Andersonian. This was a favourite

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subject of the Doctor's, and the source of the following remark appended to the announcement is not far to seek:—"It is humiliating to observe so much apathy in the modern candidate for medical honours, who will not improve himself with one idea that is not absolutely required of him." Dr. Scouler was a zealous partisan of the Liberal cause at this period, when the agitation for Parliamentary Reform had reached a crisis, and his name appears in the membership of the Crow Club in 1831-32—a social fraternity composed of adherents of the old Whig party in Glasgow.

In 1833 Dr. Scouler was appointed Professor of Mineralogy to the Royal Society of Dublin. Soon after entering upon his duties he was allowed to substitute geology and zoology for the restricted subject which he had been appointed to teach. Access to an unlimited supply of books gave him opportunities of pursuing a variety of literary reseaches, of which he availed himself with untiring assiduity. The history and antiquities of Ireland engrossed much of his attention for many years; and it was during his residence in Dublin that he commenced a translation of Aristotle's work on Animals, which he completed on his return to Glasgow. A translation of the great naturalist of antiquity, by a scholar and a zoologist such as Dr. Scouler, could not fail to be a valuable boon, both to the student of Greek literature and of natural history; and many were the solicitations addressed to the translator by his friends, to give this laborious production to the world; but, for some peculiar reason, he withstood their entreaties, and the translation, together with a valuable collection of works on Aristotle, are now deposited in Stirling's Library, Glasgow, to which they were bequeathed, along with the whole of the testator's books, including many of great rarity.*

After spending twenty-one years in Dublin, Dr. Scouler resigned his office, the Royal Society giving him two-thirds of his salary as

* It may not be unimportant to record here the terms of Dr. Scouler's bequest:—"I bequeath to Stirling's Library the whole of my books and manuscripts; and as a number of the said books are of great rarity, I direct a special catalogue of such of them as the directors of the library shall consider to fall under that description shall be forthwith prepared by them according to the best of their judgment; and none of the books in that catalogue shall in all time thereafter be lent out, but shall be retained for perusal only within the reading-rooms of the said library. And, in particular, it is my wish, and I direct, that my collection of works on Aristotle, my editions of his works, and his Greek commentaries, together with the works on logic and metaphysics in my possession, and those on natural science, shall be kept apart as a special collection, and shall not be lent out of the said library."

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a retiring allowance. The state of his health in 1853, and again in 1854, induced him to visit Portugal, where he made long pedestrian journeys, mingling freely with the peasantry, towards whom he ever afterwards cherished a warm attachment, and making himself familiar with the natural history of the country. He also made a tour through Holland, one of his objects being to pick up commentaries upon Aristotle and upon Descartes—the latter, along with Sir William Hamilton, being his favourite metaphysicians amongst the moderns. In later years he made excursions for geological and antiquarian purposes in Denmark, Norway, and Sweden; but of neither his former nor his more recent wanderings does he appear to have preserved any memoranda. He returned in 1854 to his native city, where the rest of his days were spent, still pursuing his favourite studies, lecturing occasionally, and superintending the Andersonian Museum. In summer he was the constant companion of Mr. Smith, of Jordanhill, in his yacht, cruising about the coast on dredging excursions, or exploring the "Clyde beds" for glacial shells. Before leaving Ireland, Dr. Scouler contributed notes and an appendix to a volume from the pen of the Rev. David King, LL.D., entitled "The Principles of Geology Explained and Viewed in their Relation to Revealed and Natural Religion." The notes and appendix relate both to zoology and geology; and amongst the topics treated in a brief but compendious way are—"The revolutions of the organic kingdoms revealed by geology;" "Provision in creation for unity, variety, and beauty, as well as utility;" "Doctrine of the transmutation of species," as expounded by Lamarck and De Maillet; and "Recent appearance of Man." These questions had been raised by the author of the "Vestiges of the Natural History of Creation," and Scouler treated them from the point of view of an adherent of the school of Cuvier, and of a staunch defender of the doctrine of final causes. In the preface to the book Dr. King gratefully acknowledges the services of his friend Dr. Scouler, "whose general eminence (he says) as a man of science is well known both within and without the scientific world, and whose superintendence of the Geological Department at the meeting of the British Association in Glasgow (in 1840) elicited universal admiration." On the appearance, some years subsequently, of Mr. Darwin's work, Dr. Scouler communicated to the Glasgow *Medical Journal*, a paper entitled, "Views, Ancient and Modern,

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on the Origin of Species," in which he combated the leading features of the author's theory.

Dr. Scouler was president of the Geological Society of Glasgow from 1859 to 1862; afterwards, under the presidency of his friend Mr. Smith, he held office as one of the vice-presidents till 1867. In all its proceedings he evinced a lively interest, and his ready and valuable assistance in the description and identification of specimens in palæontology was highly appreciated by the members.

Dr. Scouler, while in Ireland, examined several of the rarer Carboniferous fossils of that country, and prepared MS. notes upon them. Professor M'Coy (a pupil of Dr. Scouler's), in his *Synopsis of the Characters of the Carboniferous Fossils of Ireland*, refers to these MS. notes, and uses the names proposed by Scouler for those undetermined species which he describes in his work. Professor M'Coy also names several species after the Doctor, in honour of his researches. Of the Scottish species of Carboniferous fossils named by, or in honour of Scouler, the following may be taken as an example. In the *Edinburgh Journal of Natural and Geographical Science* for June, 1831, he published the description of a fossil crustacean animal found in a limestone quarry at Kirkton, near Bathgate. This animal, which was very well figured in a plate accompanying the description, he proposed to refer to a new genus to be named *Eidothea*. The *Transactions of the Royal Society of Edinburgh*, Vol. XIII., 1836, contain a contribution from the pen of Dr. Hibbert, in which the following incidental reference is made to "some singular creatures" which had turned up in the Kirkton limestone:—"No fewer than five specimens were at one time discovered of crustacean animals of extraordinary large dimensions. Unfortunately these specimens, in their broken state, were soon dispersed. A very able naturalist of Glasgow, Dr. Scouler, at present Professor of Mineralogy in Dublin, obtained the sight of a portion of one of these animals, which he described under the name of *Eidothea*. It exhibits a physiognomy so human-like, that the quarrymen attributed it to some degenerate offspring of Adam. For this reason, as well as in reference to the sort of examination which it seemed to invite, the animal might have been styled the '*Eurypterus phrenologicus*.' A more suitable specific title is, however, suggested. In honour of the naturalist who has described

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in a satisfactory manner the only fragment, namely, the head and a small portion of the abdomen, which came under his observation, I propose to name the Eurypterus found at Kirkton, the *Eurypterus Scouleri.*" Dr. Hibbert had succeeded in referring the fossil to the American genus *Eurypterus*, by comparing specimens of the latter with Dr. Scouler's (which had been deposited in the Andersonian Museum), together with some of the dispersed fragments which were recovered by the late Dr. John Reid, then of Bathgate, and the late Sir James Simpson, who commenced his medical practice in the same town. All the known specimens are at present in the hands of Mr. Henry Woodward of the British Museum, with the view of the *Eurypterus* being re-figured for the Palæontographical Society.

The writer of an obituary notice of Dr. Scouler, in the *Glasgow Herald*, who mentions that he first met with him in the dissecting-room of La Pitié in Paris, where they cemented a friendship which continued uninterrupted till the Doctor's death, gives the following description of his habits some years before his death, which is too characteristic to be lost:—

"Those who knew Dr. Scouler intimately, somewhat more than twelve years ago, will recognise the fidelity of the following sketch. They will recollect that he then resided at the corner of Sauchichall and Elmbank Streets. On going to visit him their nostrils were at once saluted with the odour of tobacco, and on entering, the Doctor was found, dim-discovered through the smoke. When vision became at length distinct, the room was a perfect litter of books—every chair and table groaning under them. Conspicuous among them all were three folios which were never absent—Aristotle, Hippocrates, and Ruddiman's edition of George Buchanan, who was also an idol. The other books were in all languages; for, besides the vernacular and the two learned tongues, Dr. Scouler was acquainted with the languages of France, Italy, Portugal, Spain, Germany, Denmark, Norway, and Sweden, and had also a smattering of the languages of the North American Indians. One table and the chimney-piece were generally reserved for bones and geological specimens, but most of these and his anatomical preparations were kept in a closet behind, into which he now and then disappeared to bring forth some specimen illustrative of his discourse. The central table was covered with manuscripts, and in the middle of it was a mound of cut tobacco, from which the Doctor from time to time replenished his pipe."

It was in circumstances not dissimilar, in later years, when the Doctor's social intercourse was limited to a few intimate friends, that they were wont to enjoy the charms of his conversation, and when, on the slightest suggestion of a good listener, he poured out his knowledge, alike ample and accurate, on topics the most diversified. It is to be lamented that a portion of the leisure of

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these placid years had not been devoted to the arrangement of his papers for publication; for it cannot but be admitted by his best friends that Scouler has left no work behind him worthy of his great powers and his vast attainments. When his last illness assailed him, he was not slow to apprehend the certainty of its fatal issue. It was lingering and painful, and he sought patience and comfort in religious reading and meditation. His principal book now was the Bible. On one occasion he expressed a desire to read once more the autobiography of Cowper's friend, the Rev. John Newton, which wish was readily gratified. He was repeatedly found perusing in Swedish the "Death-Song of Eric," a beautiful and touching expression of profound contrition and humble Christian hope, and breathing a spirit which reminds one of the fifty-first psalm. With his fine faculties unclouded and unenfeebled, he was able to mark with professional sagacity the progress of the disease, and, nearly a fortnight before, he predicted the exact day when the struggle would terminate. All the while he contemplated the approach of death with the composure of a philosopher and the faith and hope of a Christian. He gently fell asleep on the 13th of November, 1871, aged 67 years, and his remains rest in the churchyard of Kilbarchan.

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PROCEEDINGS FOR THE YEAR 1871-72.

Annual General Meeting, October 19, 1871.

Mr. Edward A. Wünsch, *Vice-President*, in the Chair.

ANNUAL REPORT BY THE COUNCIL.

Mr. D. Bell, Secretary, read the Report for the past year, of which the following is a summary :—

Membership.—The number of members at present on the roll is 175. It has been found that the losses by removal and otherwise average between 20 and 30 annually, which number the friends of the Society should endeavour to have made up by new members during the year. In the centre of a population such as that of Glasgow, and with the growing interest in geological studies that characterises our time, this should not be difficult.

Monthly Meetings.—The interest of the ordinary meetings of the Society has been well sustained. Several important papers were read on subjects of Local Geology ; and many interesting specimens were exhibited —some new to science—and chiefly from the Carboniferous and Post-Tertiary deposits.

Elementary Lectures.—A series of Lectures on Elementary Geology was delivered by some of the office-bearers at the mid-monthly meetings of the Society, and proved exceedingly useful and attractive.

Transactions.—The Council congratulate the members on the issue of a valuable Catalogue of the Carboniferous Fossils of the West of Scotland, with a useful Index to Localities, for which the Society is indebted to their late Secretary, Mr. James Armstrong, in conjunction with Mr. John Young, V.P.

Library.—A sub-committee was appointed during the summer months to revise the Library. The Transactions and Proceedings of other Societies continue to be regularly received, and other valuable additions are made from time to time, partly by purchase and partly by donation.

Excursions.—The field excursions during the past year were, on the whole, very successful. The localities visited were Dumbarton and Bowling, Craigenglen, The Whangie and Ballagan, Auchinskeigh, and Giffnock.

The Council invite the co-operation of all who may have any facts or observations bearing on the science to communicate, or who take an interest more particularly in the Geology of the West of Scotland.

The Treasurer, Mr. Wright, C.A., then read an Abstract of the Accounts for the year, and the report was unanimously adopted.

Mr. James Thomson, F.G.S., read some "Notes on the Plagiostomous Fishes of the Coal Measures." (See p. 187.) The paper was profusely illustrated by microscopic sections, which the members examined with much interest.

The Chairman conveyed to Mr. Thomson the thanks of the meeting.

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NOVEMBER 2, 1871.

Mr. JOHN YOUNG, *Vice-President*, in the Chair.

Messrs. Chas. B. Renshaw, Thomas Rowan, Richard Anderson, Richard Russell, John Milne Watt, Thomas D. Smellie, Thomas Renton, James Russell, Joseph Somerville, William Morrison, jun., and James Irvine were elected Resident Members.

Mr. THOS. NAISMITH exhibited a fine collection of teeth of fishes from the Carboniferous limestone near Beith. The collection included specimens of large palatal teeth, such as *Psammodus rugosus*, and *porosus*, and *Cochliodus contortus;* also of cutting teeth, as *Petalodus Hastingsiæ*, *Ctenoptychius serratus*, &c.

The CHAIRMAN made a few remarks on the collection, and Mr. Naismith received the thanks of the meeting.

A paper was then read "On the General Conditions of the Glacial Epoch, with Suggestions on the Formation of Lake Basins," by Mr. John Curry, of Eastgate, Darlington. The author stated that, during a number of years past, he had been investigating the superficial deposits in the North of England. Over a considerable area of the northern part of the Pennine chain he found that the rocks, at their outcrops, have been rifted by an uplifting and expansive force, which had been greatest at the surface, but which had diminished into the hills till it became *nil*. The accumulations lie in largest quantities on those slopes to which the strata dip, and least on those from which they dip. From each outcrop they extend and thin off in the down-hill direction so as to form a series of overlapping wings, the greatest being formed by *débris* from strata on and near the tops of the ridges. From such facts he concluded that the North of England had been covered by a thick sheet of snow and ice, and that the ice had taken up rock materials into its mass, carrying them outwards from the watersheds and laying them down in the manner described. He then proceeded to consider the general conditions of the Glacial Epoch, as elucidating the phenomena of such post-tertiary accumulations. He referred to the advance of the great northern ice-cap from north to south ; the lifting of water from the land and ocean surfaces, near the southern margin of the cap, and its storage as ice on the land ; the lessening of the ocean due to such storage ; the augmenting of the ocean while the ice was dissolving ; and the reciprocal attraction between the ice and the oceanic waters. This was followed by a description of the operations of rifting and denuding the rocks, and of carrying the wastes outwards from the watersheds. "In winter the frost would penetrate the strata to certain depths, exercising a rifting power, and causing the detached fragments to be taken up in the ice-sheet. During the ensuing summer some of the ice which enclosed rock fragments would be melted, leaving some of them to slide a little downward. At the same time the ice, which had penetrated the rocks, and which had acted like so many fine wedges driven in to open them, melted also, leaving the rocks to fall back again into their former

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position, or nearly so. By this mode of action a pulverising of the materials would be produced, and the finer portions retained, the close-fitting ice-sheet not permitting them to be removed. By the return of another winter the frost would penetrate and rift the rocks still deeper, and add more detached fragments to the ice-sheet. It would also extend farther down the slopes to produce similar results in the rocks in succession; but as summer followed, more ice would again be melted at the surface, and also that reaching into the rocks, in consequence of which the strata would come closer together to produce such a grinding effect as had been described." The processes thus pointed out he viewed as competent to carrying the rock wastes outwardly from the ridges, and leaving them in the condition in which they are now found. The author concluded by applying these processes to the formation of lake basins. For such excavations he conceived that a liberal supply of water was necessary, and that, as in the operations previously described, the work was mainly done by the expansive power of water in taking the solid form. The rock basins were evidently the places where water had been well supplied. He further suggested that the great cold might cause a diminution of volume of those parts which were under the massive ice-covering, especially when the ice was melting, and the very cold water penetrating into the rocks.

Mr. BELL said it might seem ungracious to take exception to a paper which had been received from a distance, but he supposed it had been submitted to them for the purpose of eliciting an expression of opinion from the members of the Society. He therefore took the liberty of saying that he differed from the author in many of the views or theoretical conclusions set forth in the paper. He questioned altogether this alleged lifting and falling of the strata under the action of the ice, and the pulverising effect which was ascribed to it. If the ice exercised this expansive force in the body of the rocks, how could they be described as contracting and diminishing in volume under its influence? With regard to lake basins, the author apparently first supposed them to have been formed, and then applied the water in them to account for their formation.

Other members having made a few remarks,

The CHAIRMAN held that the author's theory was open to many objections. He referred to the views which Mr. Croll had published some years ago on the influence which the shifting of the polar ice might have on the earth's centre of gravity, and thereby on the sea-level in either hemisphere. This, however, which was highly probable, was quite different from what the author had propounded. With regard to the ice penetrating to any depth into the strata, and alternately raising and depressing them, he alluded, among other instances, to the hard compact sandstones of Craigmaddie, in the neighbourhood of Glasgow, which were highly glaciated, and yet which had evidently never been disturbed by any such process as the author had described.

Mr. JAMES THOMSON, F.G.S., submitted some portions of curiously-spotted clay which he had obtained during the recent excavations to the

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east of the Old College. He stated that the occurrence of white spherical spots in the Old Red Sandstone, particularly in the neighbourhood of Dumbarton, had often been remarked by the members, and various opinions had been expressed as to the probable cause of the discoloration. Having observed similar spherical markings in a bed of dull red clay which was being excavated near the Old College, he secured several portions of it, which, after drying, split freely and exposed both discoloured spots and lenticular patches similar to those found in the Old Red Sandstone referred to. On examination, he observed in the centre of each discoloured spot faint indications of some foreign body, which, on close scrutiny, proved to be decayed vegetable matter; and on further breaking up the clay, he found the matrix around this vegetable matter always more or less discoloured, while the fibrous or woody matter itself was nearly black. He suggested that the phenomenon was due to the chemical affinity of the oxide of iron in the clay to the constituents of the vegetable matter, and that the discoloured spots in the Red Sandstone might be due to a similar cause, though no trace remained of the organism by which they were occasioned.

NOVEMBER 16, 1871.

Mr. E. A. WÜNSCH, *Vice-President*, in the Chair.

The first of the Special Lectures for this Session was delivered by JAMES BRYCE, Esq., LL.D., F.G.S., &c., "On the Geology of Skye and Raasay." After referring to the wonderful scenery presented by the mountains and coast of Skye, the author described the succession of Liassic and Oolitic beds in that island and Raasay, and enumerated the leading or characteristic fossils of these deposits. He also proposed some modifications on the arrangement adopted by preceding authors, the evidence for which he purposed to bring more fully before the Society on another occasion. The lecture was interesting and instructive, and a cordial vote of thanks was awarded to Dr. Bryce at the close.

NOVEMBER 30, 1871.

Mr. E. A. WÜNSCH, *Vice-President*, in the Chair.

The second of the Special Lectures was delivered by Dr. ROBERT BROWN, M.A., F.R.G.S., President of the Royal Physical Society of Edinburgh, on "Greenland, its Physical Geology and Fossil Flora." After alluding to the interest which Greenland possessed, as presenting a picture of what the British Isles were suppposed to have been during the glacial period, that is, thickly covered with ice and snow, Dr. Brown gave a graphic sketch of the coast scenery of the country, which he compared to a succession of islands, with water on the one side and ice on the other. He described the interior of Greenland as one vast sheet of ice of great thickness, pressing out on all sides to the sea, and occupying as separate glaciers

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the fiords which indent the coast. These glaciers in many instances push their way out to sea, where portions are broken off and drift away as icebergs; in other cases, the glacier dissolves near the head of the fiord, and great stores of muddy water escaping from it form a deposit of fine clay, which has sometimes silted up part of the fiord so effectually as even to turn the glacier aside into another channel. From what he had observed in Greenland, he was inclined to hold that the lower *till*, or boulder clay, as it exists in our neighbourhood, was formed by such a sheet of massive land ice slowly moving over the country, while what he had described as resulting from the waste of the glaciers near the sea might account for some of the well-known beds of laminated clay associated with that deposit. He questioned whether icebergs really did much in the way of conveying rocks or *débris* to any distance. So far as he had observed, they bore wonderfully little of such material in or upon them; and he thought that to call in their agency, as had sometimes been done, to account for the dispersion of plants, &c., was highly visionary. He then alluded to the rock formations of Greenland, and to the plant remains of the carboniferous and middle tertiary periods which had been found in the country, showing that it once enjoyed a very different climate from that to which it is now subjected. The carboniferous plants had only recently been discovered by Dr. Pfaff, and he trusted that gentleman, who was resident on the spot, would be enabled to make further researches.—Dr. Brown received the cordial thanks of the meeting.

DECEMBER 14, 1871.

Mr. E. A. WÜNSCH, *Vice-President*, in the Chair.

Mr. Robert Mason, Secretary of the Natural History Society of Glasgow, was elected a Resident Member.

Professor Edward Hull, M.A., F.G.S., &c., Director of the Geological Survey of Ireland, was elected an Honorary Member of the Society.

Rev. H. W. Crosskey, F.G.S., Birmingham; Mr. James Horne, Eastbourne, Sussex; and Mr. James Farie, Canonbury, London, were elected Honorary Associates.

Mr. T. F. Jamieson, F.G.S., of Ellon, Aberdeenshire; Mr. John Ward, of Longton, Staffordshire; and Mr. William Molyneux, of Burton-on-Trent, were elected Corresponding Members.

Mr. JOHN YOUNG, V.P., read a paper "On a Section of Strata containing Beds of Impure Coal and Plant Remains at Glenarbuck, near Bowling." (See p. 123).

Mr. DUGALD BELL read some notes on "The Pitchstone Vein of Corriegills, Arran." (See p. 190).

Mr. JAMES THOMSON, F.G.S., read a paper on "The Stratified Rocks of Islay."

[This paper, illustrated with maps and sections, will appear in the next Part of the "Transactions."]

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JANUARY 11, 1872.

Mr. JOHN YOUNG, *Vice-President*, in the Chair.

Mr. John Duncanson, builder, Derby Street, was elected a Resident Member.

Mr. THOMAS NAISMITH exhibited a fine collection of Corals, Crinoids, &c., chiefly from the Carboniferous limestones of the West of Scotland, and gave some interesting notes on the nature and affinities of these organisms, and their representatives in the Polypi, Sea-Anemones, Sea-Urchins, and Starfish of the present seas.

Mr. JOHN BURNS submitted a specimen of Fossil Wood from Auchinlee Quarry, being portion of a trunk which was found embedded there, under 60 feet of sandstone. He called attention to the fact of the woody structure being very perfectly preserved in this specimen, and stated that portions of it when burnt emitted a little flame. He had pleasure in intimating that Mr. Yates, the contractor, from whom he had received the specimen, had kindly presented it to the Society's Museum.

The CHAIRMAN said Mr. Naismith's collection was of much interest, as illustrating several extinct groups of Radiated animals which abounded in the seas of the ancient world. The Crinoids, or "stone lilies," which were fixed to the sea bottom by a jointed or flexible stalk, were especially abundant during the Palæozoic period, but are now represented by only a very few living forms, one of which had recently been discovered in the course of the deep-sea explorations that had been made in the bed of the North Atlantic. With regard to the fossil wood brought under their notice by Mr. Burns, although remains of plants were not uncommon in our Carboniferous strata, yet specimens showing the original woody structure were so rare as to make it desirable that every such one that was found should be preserved for microscopical examination. The one before them would be carefully examined in this way; but meantime he was inclined to regard it as belonging to the *Coniferæ*, which were the only exogenous trees yet discovered in our coal measures. These Coniferæ seem to have grown upon more elevated tracts of ground than the Lepidodendra, Sigillariæ, &c., found in connection with our coal seams, and to have been carried down by floods, and so embedded in the sandstone strata, where they are now found. Whether they all belonged to the same genera or species, could only be determined by carefully-prepared microscopic sections. He conveyed the thanks of the meeting to the exhibitors and to Mr. Yates.

Mr. JAMES THOMSON, F.G.S., read a paper on *Palæocoryne Scoticum*, &c. (See p. 188.)

JANUARY, 25, 1872.

Mr. E. A. WÜNSCH, *Vice-President*, in the Chair.

Sir William Thomson, LL.D., F.R.S., &c., was elected an Honorary Member.

Mr. John Farquhar, Lenzie, and Mr. Matthew Forsyth, 3 Hopetoun Place, were elected Resident Members.

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Mr. CHARLES LAPWORTH, of Galashiels, read a paper on "The Silurian Rocks of the South of Scoland." (See p. 164.)

The paper was illustrated by a map and sections, and a copious collection of fossils. At the close, a cordial vote of thanks was awarded to Mr. Lapworth for his kindness in reading the paper to the Society.

FEBRUARY 8, 1872.

Mr. E. A. WÜNSCH, *Vice-President*, in the Chair.

Dr. John M'Laren, 2 Canning Place; Mr. James Stewart, St. Vincent Place; Mr. Maxwell Miller, and Mr. Edward Primrose, 31 Washington Street, were elected Resident Members.

The Society then elected its Office-bearers for the present session, and the Council was accordingly declared to be constituted as under :—

President—Sir WILLIAM THOMSON, LL.D., F.R.S., &c., Professor of Natural Philosophy, Glasgow University.

Vice-Presidents—EDWARD A. WÜNSCH, JOHN YOUNG, JAS. THOMSON, F.G.S.

Joint-Secretaries—DUGALD BELL, 27 Lansdowne Crescent; JOHN BURNS, 97 Bothwell Street.

Treasurer—JOHN WIGHT, C.A., 150 Hope Street.

Librarian—THOS. NAISMITH, 233 Duke Street.

Other Members of Council—DAVID SANDEMAN, JAMES DAIRON, D. C. GLEN, JOHN ORR, ARTHUR PRATT, DAVID ROBERTSON, F.G.S.; DANIEL WILSON, ALEX. DREW, JAMES ARMSTRONG, ARCHIBALD ROBERTSON, GEORGE R. ALEXANDER, ÆNEAS M'MASTER.

Professor JOHN YOUNG, M.D., F.G.S., University of Glasgow, late President of the Society, and Professor M. L. DE KONINCK, of Liege, were elected Honorary Members.

FEBRUARY 22, 1872.

Mr. JAMES THOMSON, F.G.S., *Vice-President*, in the Chair.

The following were elected Resident Members :—Mr. James M'Farlane, 42 Bath Street; Donald Cameron, 27 Pembroke Street; David Robertson, 201 West George Street; William Scott, 63 Corunna Street; Robert Peebles, 126 North Frederick Street; Sigismund Schuman, 12 Royal Bank Place.

A paper was read from Mr. G. H. KINAHAN, M.R.I.A., "On the Formation of Valleys and Lake Basins, with special reference to Loch Lomond," &c. (See p. 181.)

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In the course of the discussion which followed, and in which Mr. Young and others took part, some doubt was expressed as to the correctness, in certain points, of the conclusions at which Mr. Kinahan had arrived. In particular, some of the members questioned whether the valleys, ravines, and lake basins in Scotland were so uniformly connected with breaks or faults in the strata as the author had stated. Further proof of the "post-glacial dislocations," to which he had referred, was also desired. And the existance at any time of a subterranean outlet from Lochlomond was thought to be most improbable.

The CHAIRMAN moved the thanks of the meeting to Mr. Kinahan for his kindness in transmitting the paper to the Society.

MARCH 7, 1872.

Mr. JOHN YOUNG, *Vice-President*, in the Chair.

The following were elected Resident Members:—Messrs. Thomas Annan, 202 Hope Street; John M'Gregor, 80 North Frederick Street; Peter S. Hyslop, 97 West Regent Street; Archibald Gardiner, 97 West Regent Street; James Young, Lochview, New Kilpatrick; John Dunsmore, Kirkintilloch.

The CHAIRMAN took the opportunity of referring to the appointment, which had just been intimated, of Professor A. C. Ramsay, F.R.S., as Director-General of the Geological Survey, in the room of the late Sir Roderick Murchison. From Professor Ramsay's former connection with Glasgow and the West of Scotland, he thought this intelligence would be interesting and gratifying to the members.—The announcement was received with much applause.

A note was read from Professor Hull, F.R.S., honorary member, "On a Remarkable Fault in the New Red Sandstone at Whiston, Cheshire." The thanks of the meeting were moved to Professor Hull for his kindness in forwarding the communication to the Society.

The CHAIRMAN exhibited a small but characteristic specimen of the palatal tooth of *Ctenodus cristatus*, a placoid fish of the Carboniferous system, discovered by Mr. E. A. Wünsch, V.P., in the Trappean Ash-beds at the base of the Carboniferous formation in the Island of Arran. A large specimen of the same tooth from the upper Coal measures of Lanarkshire was also exhibited, as illustrating the great vertical range of this genus throughout our Coal strata. So far as yet discovered, it seems to be restricted to the fresh-water series of deposits, no marine organisms being found either in the Arran plant beds or in the other strata of the Lanarkshire coalfield in which the remains of this fish occur.

Mr. ROBERT CRAIG, Langside, Beith, corresponding member, then read a paper on "The Glacial Deposits of North Ayrshire and Renfrewshire." (See p. 138).

The discussion of Mr. Craig's paper was postponed till next meeting.

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MARCH 21, 1872.

Mr. JAMES THOMSON, F.G.S., *Vice-President*, in the Chair.

The Rev. WILLIAM FRASER, LL.D., of Paisley, corresponding member, read a paper on "Some Recently-exposed Sections in the Paisley Clay-beds, and their Relation to the Glacial Period." (See p. 178).

Mr. JOHN YOUNG, Vice-President, agreed with the author as to the general succession of the beds described, with the exception of the so-called overlying bed of upper boulder clay. He would suggest that, in the centre or neighbourhood of a town like Paisley, where excavations had been going on for a long time past, it was possible that diggings into the lower boulder clay may have been removed and laid down over more recent deposits; or former excavations into the hillside, flanked by the deposits in question, may have produced a slip of the boulder clay forming the crown of the hill, down over these more recent beds. He had seen an analogous instance during the excavations at Gilmorehill; and it was well known that geologists of eminence had sometimes been misled by surface deposits in the vicinity of towns, and the conclusions based upon these had afterwards been proved to be fallacious. He therefore urged caution in the acceptance of the view that this upper boulder clay had been laid down by ice subsequent to the formation of the shell-bed, which appeared to be of such recent origin.

Mr. CRAIG was inclined to hold that the overlying boulder clay had been formed as Dr. Fraser had suggested.

Other members having made a few remarks, Dr. Fraser briefly replied, and received a cordial vote of thanks for his paper.

The adjourned discussion on Mr. Craig's paper (see p. 138) was opened by Mr. DUGALD BELL, who said he did not think that Mr. Craig's theory of two general glaciations—first, from the N.E. by land ice, and second, from the N.W. by drift ice—would hold good. No doubt there are two or more distinct sets of striæ found in many parts of the country, though it is not always easy to determine their relative age, or the means by which they were produced. It may be admitted, however, that in the Beith district the older striæ are from the N.E., and are in all probability the work of land ice; also, that there are in many places in the same district newer or more recent striæ from the W. and N.W., which seem to be due to drift ice; but it does not follow that the same things in the same order are to be found over the whole country, and far beyond it.

In point of fact the striæ are found in different parts of the country bearing from every point of the compass; and even when the two sets which Mr. Craig has fixed on are found together, or in juxtaposition, it is by no means invariable that the N.E. set appear to be the older, and the N.W. the newer; or that the former seem to be due to land ice, and the latter to drift ice. The opposite, in both respects, is sometimes found to be the case.

The *Forth and Clyde valley*, for example, is striated in a general direction from N.W. to S.E. No proof from any part of it has been adduced of an

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older striation from N.E. These N.W. striæ maintain a great uniformity of direction, both over the lower grounds and up the faces and along the slopes of hills,—from which the conclusion fairly led to, and now generally acquiesced in, is, that they must be the work of land ice. This conclusion is further confirmed by an examination of the overlying boulder clay. Not only is it packed full of fragments of rocks from the north-west, mingled with local varieties, of all sizes and in all positions, most of them distinctly striated,—but, passing from W. to E., it is found to undergo partial changes in colour and composition, corresponding with the strata over which it has passed. Mr. Craig's theory obliges him to view all this N.W. striation of the Forth and Clyde valley as the work of drift ice, and the overlying boulder clay as "upper" or "re-assorted" clay—not true *till*. The facts in both respects are quite against him. These striæ are entirely different from anything drift ice could produce. And that hard, stiff, stony clay which rises in mounds and 'ridges all round this city, and which meets us in almost every cutting, is unquestionably genuine boulder clay or *till;* otherwise the same thing bears different names in different places, and there is no certainty, indeed nothing but confusion, in the matter.

It is obvious that even one instance of true *till* overlying N.W. striation is fatal to Mr. Craig's theory, as the older clay must have been entirely swept away before the rock beneath could be striated by drift ice.

Let us turn now to Mr. Craig's remarks on *Seedhills* and *Kilmalcolm*, and the argument in favour of drift ice which he educes from a comparison of these two sections. The Kilmalcolm section, though only two miles from the outcrop of the Old Red Sandstone behind Port-Glasgow, but about 100 feet higher, shows only four per cent. of Old Red boulders. Seedhills, at twelve miles distance from the outcrop, but 200 feet lower, shows 24 per cent. These facts, Mr. Craig thinks, would be reversed had the transport of the boulders been due to land ice. This, however, is not quite certain. There is no necessity for supposing that exactly that part of the ice sheet which passed over Seedhills had previously passed over Kilmalcolm. While the Old Reds at Kilmalcolm were doubtless derived from the outcrop near Port-Glasgow, those at Seedhills may have been—most probably were—derived from the hills, a little more to the north, which bound the Vale of Leven, where the sandstone attains a height of 800 or 900 feet. But Mr. Craig accounts for the facts by drift ice in this way:—Before Kilmalcolm became submerged so as to allow bergs to pass over it, the Old Red would be deeply buried beneath the water. Hence the *paucity* of this variety of boulders in the Kilmalcolm section. But the reason given proves too much; it won't admit of a *few*—it requires there should be absolutely *none*. *The presence of even one boulder that has admittedly been brought from a lower level is conclusive against the notion of its having been brought by drift ice.*

Further, it is evident that drift ice, after passing over Kilmalcolm, could not have touched ground, or grooved and polished a rock at Seedhills. If the N.W. striæ at the latter place were produced by drift ice, it must have come round in some other way. The ice, of course, would only touch ground where the water became too shallow for it; and this, too, after it had been

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lightened considerably by waste and droppage in its progress. The lower the level, therefore, at which striæ *produced by drift ice* are found, the less choice of ways is there by which it could have come; its route must have been over some tract that was still more deeply submerged.

But having got to Seedhills—supposing it to have been drift ice from the N.W.—the question arises, Where was it *driving to?* There is "no thoroughfare" for it that way. A short distance behind rise the Gleniffer and Fereneze hills, and there is no sufficient opening by which it could get through and pass on. On the other hand, we find N.W. striæ sloping up and along these hills in a way that puts drift ice out of the question. In short, at Seedhills, as at Kilmalcolm, the evidence is distinctly in favour of the N.W. striæ being due to land ice. Both sets at Seedhills may be due to the same agency; but if either of them be the work of drift ice, it is much more likely to be the *N.E. to S.W.* set, which points directly to the Lochwinnoch valley, through which, during the period of submergence, a strong current must have flowed.*

A few words now on the *Beith* district itself. It has not been satisfactorily made out that the "two clays" in that district are so invariably associated with the two sets of striæ, that the lower clay or *till* is never found overlying N.W. striation. The author's practice of calling everything "upper clay" that overlies N.W. striation, simply because it does so, and without any other perceptible reason (as at Kilmalcolm and other localities already referred to), is entirely misleading and open to question. He appears, in fact, to make the striæ the sole test or mark of the clay, so that when they are absent he hesitates to say whether it is "upper" or "under." Thus the clay at Garval Park—true *till* unquestionably, if there is such a thing—is marked "doubtful," because the striæ were not exposed.

Again, it seems impossible that drift ice could produce a uniform set of markings in any one direction over the country. Supposing that drift ice, where it does act, can make regular grooves and striæ—which is doubtful—it is plain that during the partial submergence of the land it must have acted in many various directions, according to the shore-lines and the bearing of the main sounds and channels. Especially does it seem impossible that the N.W. striæ at Beith should be part of a general system produced by drift ice, and extending over the whole country. Beith is situated under the

* Mr. Craig has no doubt described with perfect accuracy the appearances at the time he saw them. But during at least half a-dozen visits to Seedhills, at a subsequent time, extending over as many months, the N.W. set were seen to be decidedly the more evenly continuous, and like the work of land ice: while the N.E. set were confused, indistinct, and scratchy. This shows that too much weight ought not to be attached to conclusions drawn from a limited surface.—We may also note that in Mr. Craig's "Table of Boulders," which has evidently cost him a great deal of labour, the method of not admitting any results that cannot always be accepted as literally correct. For example, Planetreeyetts below a certain size (the only practicable one, no doubt, if *counting* be adopted) gives shows about 17 per cent. of metamorphic erratics over 3 inches in diameter—Seedhills only 9½ per cent. This difference in the enumeration, we believe, is mainly caused by the erratics in the latter section being as a rule *smaller* than those in the former. It is not that there is actually such a percentage fewer of metamorphic rock in the clay at Seedhills, but simply fewer the given size. The clay at Seedhills is altogether finer and closer in texture than that at Planetreeyetts, and no one can look at it without seeing that it contains a very considerable proportion of metamorphic fragments—much more than 10 per cent. Such points must be borne in mind in comparing different sections in such tables. "Nothing is more misleading than figures," when there are elements in the case which they don't represent. (An examination of two separate parcels of the Seedhills clay, including fragments down to the size of a small nut or bean, showed at least double the proportion of metamorphics stated by Mr. Craig.)

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lee, so to speak, of the Lochwinnoch range of hills, which immediately to the N.W. attains an elevation of 1200 to 1500 feet. Bergs or drift ice, after passing over these hills, could evidently never strike or ground on this lower district behind them.

Doubtless the boulder clay has been modified and re-distributed to some extent during the period of submergence, and floating ice or bergs may have been driven in upon and over this submerged tract during that period—producing in some instances partial and irregular striæ; but this has nothing to do with any general or uniform glaciation.

It is easy to make too much of these two sets of striæ; as, taken generally, *both* may have been produced by land ice—differing in volume at different times, and "varying a little eastwards or westwards according to the form of the ground."*

Many other points in the paper must be omitted; but a few words may be added on the authorities Mr. Craig has referred to in support of his views. And, first, the late Dr. Robert Chambers. He had the merit of being among the first to adopt the theory (originally suggested by Agassiz) of a general ice covering of the country; but his views in detail differed widely from Mr. Craig's. He supposed there had been, *first*, a general glaciation by *land ice from the N. W.*, and then, in many places, a *more local* glaciation from the N.E. (Proc. Roy. Soc., Edinr. Vol. III., p. 151.) This is exactly the opposite of Mr. Craig's theory.

The reference to Mr. Jamieson, of Ellon, is also surprising, as that gentleman is well known to have wrought out, most fully and clearly, the proofs of a radiation of the ice on all hands, from the main mountain chains.

The observations of Sir R. Griffiths, many years ago, and the later researches of Messrs. Close and Kinahan, in Ireland, have conclusively established the same thing for that country.

The "glaciation of Caithness" is, in any view of it, an awkward fact for Mr. Craig—being right across one of his general systems of striation, and meeting the other in the face. It is neither from N.E. nor N.W., but *from S.E.* Referring to Mr. Croll's admirable paper on the subject, Mr. Craig asks, What kind of glacier was it that moved up the North Sea (or, rather, the German ocean), against the enormous flow of ice from Scandinavia? There is no reason for saying "against" this flow, but rather *with* it; Mr. Croll having given good and sufficient reasons why the ice from Scandinavia should have taken that direction. But we may ask what kind of glacier was it that could extend all the way from Scandinavia, and pass over this country without deviation—making Grampians and all other hills and mountains of no account in its progress? Unless Scotland were almost wholly submerged at that time—which is not maintained—the probability surely is, that its *native* ice would be sufficient to "hold its own." And what was there, with a deep sea to the north and west, to *compel* the ice from Scandinavia, or elsewhere, to scale the country in this fashion?

The notion of a continuous sheet of ice covering the entire northern

* Mem. Geol. Survey: Explanation of Sheet 22 (North Ayrshire, &c.)

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hemisphere, and having a uniform motion in any one direction, whether from N.E. or N.W., seems to be quite fallacious. Even Scandinavia, which, according to this theory would be most deeply enveloped in such a continuous sheet, was itself a centre of dispersion. Sir Charles Lyell, quoting from Norwegian geologists, shows that the erratics have been carried "towards all points of the compass, from the mountains of Scandinavia as a centre, and the rectilinear furrows imprinted by them on the polished surfaces of the mountains radiate in all directions."—(*Antiquity of Man*, p. 233.)

So it has been found in Scotland, in the north of England, in Ireland, and wherever the traces of ice action have been carefully studied, in all parts of the world.

He had only to add that, while thus commenting freely on the theoretical part of the paper, he gave Mr. Craig full credit for the zeal and perseverance with which he had investigated these glacial deposits, and for the many valuable facts and observations which, now and at former times, he had laid before the Society.

Mr. JOHN YOUNG said, while he agreed with the author of the paper, that there had been a primary glaciation of Scotland, he did not believe that it had been exclusively in one direction, nor that the few scattered patches of north-east striæ observed in Lanarkshire, Renfrewshire, and Ayrshire could be held as proving that the glaciation in these cases was the result of land ice. These patches of north-east glaciated rock surfaces were, in his opinion, more likely to have been the result of sea-borne ice, moved by currents from that direction. West and north-west striæ were those most commonly observed in the central districts of Scotland. Whether all the striæ running from these directions were the result wholly of a land glaciation remained to be proved, as well as those from north-east sources.

With regard to the so-called interglacial fresh water beds, he did not think that any of the sections brought forward by the author of the paper could be held as satisfactory, or as proving these conditions. Other observers considered that the evidence in these cases was very obscure, or that the overlying patches of boulder clay were laid down by a second ice-sheet. He believed, in most instances, that its overlying position could be explained by slips of the older boulder clay from higher levels over comparatively *recent* fresh-water deposits. None of the organisms of these fresh-water beds appeared to differ from those found in the recent Post-Pliocene deposits; yet the author of the paper would make them much older than the Post-glacial series of the Clyde, which contains many organisms not now found in these waters.

In stating that the interglacial beds of the West of Scotland are of fresh-water origin, and that the Kilmaurs beds are only overlaid by the upper boulder clay and drifts, the author seems to have forgotten that at Kilmaurs the fresh-water beds, with plants and mammalian remains, are overlaid by a marine Arctic shell bed. It also remains to be satisfactorily shown that the overlying boulder clay there is not the lower boulder clay of the West of Scotland. The Kilmaurs beds have never yet been correlated with any

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interglacial deposits containing similar organisms in any other part of the country; and until this is done we are inclined to regard them as preglacial, and the till by which they are overlaid as the *lower* boulder clay of Scotland. Moreover, true boulder clay has more often been found in the West of Scotland overlying marine beds than those of fresh-water origin, as at Kilmaurs, Croftamie, in the Endrick Valley, Airdrie, Chapelhall, and Tangy Burn, Campbeltown.

Other members having made a few remarks, Mr. CRAIG briefly replied.—He would not have time on that occasion to take up in detail the various points that had been referred to. He would merely say that though some parts of his paper might be open to criticism, he had confidence in the accuracy of his observations, and was satisfied that the conclusions to which he had been led would be fully confirmed by succeeding observers.

The CHAIRMAN then conveyed to Mr. Craig the thanks of the Society for his able and suggestive paper, and was sure he would not regret the discussion to which it had led. It was only by a careful sifting and examination, both of the facts and of the conclusions drawn from them, that a satisfactory result on such subjects would ultimately be arrived at.

MARCH 28, 1872.

Mr. JOHN YOUNG, *Vice-President*, in the Chair.

Mr. Archibald Hamilton, C.E., Clyde Navigation Office, was elected a Resident Member.

Mr. JAMES THOMSON, F.G.S., Vice-President, read some "Notes on the Rootlets or Pedicles of Polyzoa, and on a New Form of Hydrozoa, from the Carboniferous Limestone of Ayrshire."

[This paper will appear, with figures, in the next part of the *Transactions*.]

Mr. RICHARD ANDERSON, F.C.S., F.G.S., of Uddingston, read a paper on the "Origin of Petroleum." (See p. 174.)

The CHAIRMAN said he was not prepared to accept the theory that bitumen, petroleum, and other hydro-carbons were primitive compounds, engendered within the strata of the earth's crust. He believed that, in nearly every case, these compounds could be shown, by strict examination, to have been derived from beds in which organic life had been entombed; and mentioned several instances within the Scottish coalfield corroborative of this view. The numerous cases in which bitumen, rock oil, &c., could clearly be traced to strata containing the remains of plants and animals, negatived, in his opinion, the few exceptional instances in which these products are found in rocks which do not indicate whence they were derived, and rendered it probable that in every such case the ingredients in question were transfused into these rocks by distillation from strata more deeply seated, containing organic remains.

Other members having made a few remarks, Mr. Anderson briefly replied, and received the cordial thanks of the meeting for his interesting paper.

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APRIL 18, 1872.

Mr. EDWARD A. WÜNSCH, *Vice-President*, in the Chair.

The following were elected Resident Members:—Messrs. Thomas M. Barr, 21 Rose Street, Garnethill; David Walker, 239 Sauchiehall Street; John Paul, C.E., 16 Clyde Place; John Knox, 42 Bath Street; John Reid, Yorkhill Gate, Partick; Charles Reid, 261 Stirling Road; Alex Wood, Jun., Woodbank, Partick Hill; Charles Lindsay, C.E., 39 Devon Street.

Dr. ROBERT BROWN, M.A., F.R.G.S., delivered a lecture on "The Mineral Resources of British Columbia and the North Pacific Territory." He said the portion of the North American Continent to which he wished to direct the attention of the members was about 1000 miles in length, and 700 or 800 miles in breadth. All along that tract, including British Columbia and Vancouver's Island on the north to California on the south, gold mining might be said to be the principal industry of the country. Everywhere there were indications of gold, or, as Drake said long ago, "there is sign of gold in every part of the soil we take up in this country." The two chief varieties of gold mining are "placer" mining and quartz mining—the latter extracting it from the rock, the former collecting it from the alluvium, or soil and gravel, in which it is diffused. This "drift," or alluvial covering of the country, seems to date from towards the close of the glacial period. It is of great thickness in many places—sometimes 400 or 500 feet thick. It was a mistake to suppose that there was no trace of glaciation along the Pacific coast. In British Columbia, and a long way to the south of it, the traces of glacial action were quite as distinct as in this or any other country. "Placer" mining was the most common form of gold-mining in these parts, nearly two-thirds of the whole being "placer," and only one-third quartz mining. The former is essentially unskilled labour, no geological or chemical knowledge being required for it, but the latter requires more skill and experience. Of "placer" mining there were several varieties—deep "placer," by a tunnel in a hill, or a shaft in a deep soil; shallow diggings, along the banks of streams; bench digging, on the natural terraces of the valleys; bar diggings, on the sand bars at the bends of rivers, &c. He then described the sluice boxes commonly used by the miners, also the "under-current" sluices, rock sluices, tail sluices, &c. Then there was the system of hydraulic mining, where a powerful current of water is brought to bear by a large hose upon the banks, breaking and washing them down with immense force. This method in a well-watered country has the advantage of cheapness, but was only adopted where the soil was comparatively poor. It was not without danger, as sometimes the bank, being undermined, gave way unexpectedly, and accidents frequently occurred. This mode of mining was making great alterations in the physical aspect of many parts of the country. Hills were being washed down, courses of rivers changed, and once smiling valleys converted into a dreary expanse of mud, gravel, and washed boulders. Besides these there were "knife-diggings," getting down to the bed rock, the surface of which

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was often richly sprinkled with gold; river mining, or turning the course of a river, and searching in its bed—a risky and oftentimes unprofitable undertaking; and beach mining, which was carried on to a considerable extent along the coast of North California and Oregon. A good deal of gold was mixed up with the sand; it was easily washed, and sometimes proved very remunerative. After describing some of the mining contrivances, such as the "cradle" and the "pan," Dr. Brown went on to say that the sole object of the miner was to get the greatest possible amount of gold in the shortest possible time. He did not care though a good deal of the gold was lost, so long as the method he adopted gave him more in the time than a slower or more careful method would give him. There was thus a great deal of gold lost, or allowed to pass, especially in the early days of gold-mining; and in many places the Chinese were coming in and re-working parts that the "whites" had abandoned, and opened up others that had not been thought worth looking at. These Chinese had introduced some ingenious contrivances in mining. Some of their water-wheels were very elaborate. He then came to speak of "quartz mining," or extracting the gold from the veins and patches in which it occurs in the native rock. Some geologists had been of opinion that gold occurs only in rocks of Palæozoic age, but this is quite erroneous, as there was no rock in California older than the Jurassic. In California the direction of the auriferous veins was generally NN.E. and SS.W.; in British Columbia, more E. and W. In some cases they run nearly parallel with the strata, in others steeply inclined. The latter are generally the richest, those running parallel with the strata being, as a rule, very poor. The quartz considered best for gold was of a brownish or yellowish colour, though sometimes the white or bluish white quartz yielded a good supply. The gold occurred mostly in veins more or less continuous, but occasionally the adjacent or "country" rock contained a good deal also scattered through it. The lecturer then described the quartz-mills in which the rock is crushed, and the subsequent process of extracting the gold. It was estimated that a capital of 12,000,000 dols. had been invested in quartz-mills along the Pacific coast. A few of the best mines yielded from £12,000 to £15,000 per month, others about £4000. Of the total amount of gold collected annually, it was impossible to speak precisely; probably in California about 40,000,000 dols., in the other States, 10,000,000 dols., and in British Columbia, 6,000,000 dols. With regard to other metals, silver was found chiefly in Nevada, where there is an immense deal of silver-mining carried on—indeed that district, being very bleak and barren in its aspect, may be said to yield only silver, of which the Sierra Nevada range seemed to be in great part composed. In California there are very rich mines of quicksilver. Copper is found at various places in British Columbia, Vancouver's Island, &c., but not to a profitable extent, except in California. There are no smelting works, however, on the Pacific coast; the ore is also exported to Swansea to be smelted. Tin and lead are found to some extent; and iron appears also to be widely diffused. Then as to coal, it is found cropping out at various parts in California, Washington, Oregon, and on to Vancouver's and Queen Charlotte Islands. A great

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part of it seems to be of Mincene age, and but of poor quality, containing only about 46 per cent. of carbon. In Vancouver's Island there is coal of secondary age, and in British Columbia, and all along that part of the coast, the coal is much better than any to the south. Our American neighbours are understood to be fully aware of this, and are sometimes credited (or debited) with a desire to annex these parts for the sake of the coal. In conclusion, the lecturer said he would not advise any one to go a-gold-digging if he had anything else to do. It was very much of a lottery, and the only things certain about it were the rough living and hard work. The few prizes were apt to be noted, and the many blanks overlooked. There was a great deal of truth in the Mexican proverb, "To get a gold mine, a gold mine must be given."

The lecture abounded in graphic description of scenery, and narratives of mining adventure, and was illustrated by a collection of photographs representing "Life in the Far West." A cordial vote of thanks was awarded to Dr. Brown for his very interesting and instructive paper.

MAY 2, 1872.

Mr. JOHN YOUNG, *Vice-President*, in the Chair.

Mr. Gilbert Adams, 3 Hospital Street, was elected a Resident Member.

Some interesting specimens were exhibited by members, including fish remains from the Old Red Sandstone of Caithness, by Mr. Kirsop; *Lepidodendra* and other coal plants from the coal measures around Glasgow, by Mr. Somerville; and the stem of a plant, species undetermined, from a bed of volcanic ash in the trap hills near Lochwinnoch, by Mr. Bell.

Mr. JAMES THOMSON, F.G.S., read some notes "On an Undescribed *Platycrinus*, from the Mountain Limestone of Fifeshire." (See p. 189.)

Mr. DAVID ROBERTSON, F.G.S., read the following papers:—(1) "On the Clay Beds at Kilchattan, in Bute;" (2) "On a Fossiliferous Clay Deposit near Campbeltown." (See p. 128 *et seq.*)

The CHAIRMAN referred particularly to the latter deposit, and observed that this additional discovery of Arctic marine shells below the lower boulder clay of the West of Scotland was a further confirmation of the interesting fact that an Arctic or northern fauna had spread over certain tracts of the existing sea bottom before the lower till of the country was deposited. With regard to some of these beds, such as those found at Kilmaurs, in Ayrshire, and in the Endrick Valley, near Lochlomond, which present under boulder clay remains of an Arctic fauna of land and marine origin, attempts had been made by some recent writers to place them in a so-called "interglacial" series. But nothing had been adduced, either palæontological or stratigraphical, to show that these beds could be correlated with any deposits lying between boulder clay in other parts of the country. He therefore held that the evidence was at present in favour of the pre-glacial age of such beds. Another interesting fact, revealed by the washing of the boulder clay overlying the shell-bed at Tangy Burn, which

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Mr. Robertson had submitted to him for examination, was that among the rocks entering into the composition of that till, there occurred characteristic fragments of the Arran granites. This indicated that during the glacial period ice, drifting away from the higher summits of the Arran hills, had floated south-westwards, dropping its *debris* over the submerged tracts now raised above the sea level.

The Society then adjourned till October.

EXCURSIONS—1872.

April 20.—MARYHILL AND POSSIL. *Striated Rock-Surfaces and Boulder Clay.*

May 4.—GIFFNOCK. *Sandstone Quarries.*

May 18.—CORRIEBURN. *Lower Carboniferous Beds.*

May 24.—CRAIGNETHAN. *Sections of Lower Carboniferous Sandstones and Shales.*

June 1.—BEITH. *Carboniferous Limestones.*

June 8.—POSSIL. *Striated Rock-Surface and Boulder Clay.*

June 15.—MILNGAVIE AND CRAIGMADDIE. *Zeolitic Trap, &c.*

The following notes refer to one of the excursions to Possil :—

The object of our visit lay quite in the neighbourhood of the city, being simply a freestone quarry that has lately been opened, or rather reopened, at Possil. The rock here is a fine-grained, compact sandstone, which occurs lower in the carboniferous series than the well-known sandstone of Bishopbriggs. It is valuable not only for its wearing properties, but also—the strata being nearly horizontal and very continuous—for the great size and regularity of the blocks that may be detached from it. Some of these, which are now being taken out and prepared for a public work, measure from 50 to 60 square feet, and must be not less than four or five tons in weight. At one part a good seam of coal is being wrought for the use of the engines on the ground. In another place a "felstone dyke" has cut through the strata, causing a displacement to some extent, and furnishing a good example of what are called "Slickensides," as well as of the hardening effects of heat along the line of fissure. But these were not the points which we had specially come to examine.

It is well known that the thick irregular covering of boulder clay which overlies the coal measures all around Glasgow, and along the Forth and Clyde valley, is thickly charged with *debris*, which has apparently been derived from the mountains to the west and north-west—fragments of granite, quartz, schist, old red sandstone, and trap corresponding to the rocks of the Argyllshire and Dumbartonshire hills. These, taken along with the glacial markings, the grooves and striæ on the subjacent rocks, have been held to prove that there has been a great flow of ice—whether in the form of land-ice or floating bergs has been subject of much debate—

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maintaining in general a direction from west to east, carrying fragments of rock from the hilly districts referred to, and strewing them in passing over the lower grounds. Now, at the quarry we have named, there is a beautifully "glaciated" surface exposed, the sandstone being marked by long, fine straight lines and furrows, running, by compass, nearly due N.E. and S.W. At first, when the surface was only partially exposed, these were taken to indicate that the ice had moved from S.W. to N.E., being a little more from the south than was shown by other markings in the neighbourhood, but still sufficiently in accordance with what had been established to be the general glaciation of the district; and this direction the fragments of West Highland rocks, plentifully imbedded in the overlying boulder-clay, which here attains a thickness of from twenty to five and twenty feet, were held to confirm. Subsequent observations, however, had shewn that the markings in question must have been produced by ice moving in quite the opposite direction—namely, *from* N.E. *to* S.W. The geological student need hardly be reminded that it is by no means easy or safe to determine offhand, from a limited area, the direction in which the ice-stream moved. One of two opposite directions certainly is indicated, but to determine *which* may require a wider and more careful survey. Very eminent observers have occasionally fallen into error in this respect. Accordingly, as the point was of some interest, and there was no saying how important it might be in interpreting the glacial phenomena of the West of Scotland, the members now present had come—in no official capacity, but each, so to speak, on his own account—to examine and weigh the evidence regarding it.

The surface here presented by the rock, when stripped of its overlying clay, cannot fail to strike any observer as very remarkable. Not only is the general surface beautifully rounded and polished, showing the fine straight lines or striæ already mentioned, but even the sides of the little ridges that rise here and there and the hollows between them show similar markings. Nay, some vertical faces of the rock are grooved and furrowed straight along in the most wonderful manner. It seems clear, to begin with, that no floating ice grounding on the rock and moving off again could so insinuate itself into all the inequalities of the surface as the agent that produced these markings has evidently done. But now we mark that each of these little ridges or inequalities has its *sharp end* presented to the north-east, very like an upturned boat or skiff with the prow lying in that direction, while the striæ passing over it diverge a little on either side. Also that the broad ends of the ridges looking to the south-west, from which fragments in some instances appear to have been carried away, and the little hollows immediately behind them, are scarcely, if at all, touched by the markings, and present a rough and unpolished appearance. Yes,—there is no doubt the ice in this case *has* come from the north-east. But how explain the innumerable boulders of westerly origin scattered about or still imbedded in the clay? A line drawn north-easterly from this place would cross the Campsie Hills about the middle of the range, and then, cutting the great belt of red sandstone nearly at its broadest, would touch the schistose

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rocks somewhere near Dunkeld. We can scarcely imagine that these fragments of granite, quartzite, schist, &c., have come in that direction. The markings on the Campsie Hills, as well as on other parts of the intervening route, are clearly against such a supposition, being from the north-west; and thence, no doubt, these boulders have been derived. But how could they get hither, if the ice, which is supposed to have carried them, moved in the opposite direction? It was a puzzle; and there was a feeling that somehow the observations were not complete—the dissatisfaction which something unexplained always leaves in the mind—when, just at this moment, one of our number, Mr. J. Young, V.P., stepped aside to examine a face of the rock which had hitherto escaped attention, and which looked somehow different from the rest. To the surprise and delight of all present, it was found to be distinctly striated in a direction nearly at right angles to the other markings—namely, from N.W. (or a few degrees by W.N.W) to S.E. by E.S.E. The surface referred to is that of a part of the rock sloping a little to the south, and which may, therefore, be supposed to have been partially protected from the sweep of the north-east glaciation. We then set ourselves to re-examine the whole surface with greater minuteness and care, and found the same cross-markings at several other points—wherever, in short, they had a chance of being preserved from the north-east glaciation. Two or three boulders, also, with their longer axes pointing to the north-east, and well marked in that direction, were found overlying the north-west striation. The results arrived at were shortly these:—(1) There have been two distinct glaciations of this rock surface, whether both by the same agency, or the one produced under conditions differing from the other; whether the one closely following the other, or separated from it by a long interval of time, are points that must be reserved for future investigation. But (2) it seems clear in the meantime, so far as the evidence goes, that of the two that from the north-west is the older, and that from the north-east the newer or more recent. Many, doubtless, will fail to see the value or importance of these observations; but it is quite possible that this fact of two glaciations, with the order of succession as here shown, may be the key to unlock some of the difficulties connected with the boulder clay, which have so long perplexed geologists.

It may be added that when the overlying boulder clay was newly cut into, it was seen to be curiously *banded* in some places, as if by two or three layers of darker material, more coaly or shaly than the rest. The crumbling down of the surface, however, from exposure, has since concealed this feature to some extent. Such points always deserve careful attention as bearing on any theory of the formation of the deposit.

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ABSTRACT of the ACCOUNTS of the GEOLOGICAL SOCIETY of GLASGOW, for Year ending 30th September, 1871.

REVENUE.

Cash in Treasurer's hands at close of last Account,				£2	9	7
Cash in Secretary's hands at same date,				0	6	11
Subscriptions—						
Arrears for Year 1868-69,	£0	10	6			
Arrears for Year 1869-70, 6 at 10/,	3	0	0			
Subscriptions for Year 1870-71, 144 at 10/,	72	0	0			
New Members for Year 1870-71, 19 at 10/,	9	10	0			
Subscription for Year 1871-72, paid in advance,	0	10	0			
				85	10	6
Petty Receipts,				2	4	1
Drawn from Bank,				35	0	0
Balance due to the Treasurer,				2	1	7½
				£127	12	8½

Printing Transactions, to Account,	£30	0	0
Binder's Account,	3	0	6
Magazines and Transactions purchased,	2	8	0
Printing Cards, Circulars, and Stationery,	8	3	0
Subscription to Palæontographical Society,	1	1	0
Secretary's Petty Disbursments,	7	8	5½
Rent, Taxes, and Insurance,	24	14	4
Delivering Circulars and Transactions,	6	18	3
Treasurer's Petty Disbursements,	3	16	5
Lodged in Bank,	40	2	9
	£127	12	8½

STOCK.

Sundry Current Liabilities,				£25	0	0
Balance for Net Stock,				183	17	0
				£208	17	0

Cash in Bank—						
Depost Receipt,	£27	14	3			
Current Account,	6	2	9			
				£33	17	0
Publications, Fossils, and Casts,				175	0	0
				£208	17	0

GLASGOW, *9th October, 1871.*—We have examined the Accounts, of which the foregoing is an Abstract, with the Vouchers, and find the same correct.

JAMES MACAULAY,
RICHARD NEILSON, } *Auditors.*

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DONATIONS TO THE LIBRARY.

Academie Royale de Belgique. Bulletins et Annuare, 1870-71.
American Philosophical Society. Proceedings, 1871.

Belfast Naturalists' Field Club. Eighth Anuual Report, 1871.
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Geikie, James, F.R.S.E., on Changes of Climate during the Glacial Epoch. 1872.

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Nature (Journal.) Vol. IV., 1871.

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Ostracoda and Foraminifera of Tidal Rivers. By G. S. Brady and David Robertson, F.G.S.

Philadelphia Academy of Natural Sciences. Proceedings, 1871.

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Washington—Report of the Department of Agriculture, 1871.
Washington—Smithsonian Institute. Annual Report.

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ERRATUM.—Page 140, line 9. *For* 38°, *read* 3°.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW.

VOL. IV.—PART III.

PUBLISHED BY THE SOCIETY,
AT THEIR ROOMS IN ANDERSON'S UNIVERSITY BUILDINGS.
1874.

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The Editors beg to state that the Authors alone are responsible for the facts and opinions contained in their respective papers.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

XIX.—Note *on the* Occurrence *of* Erratics *at higher levels than the* Rock-masses *from which they have been derived.* By James Geikie, F.R.S.E., F.G.S., of H. M. Geological Survey of Scotland.

(Read 11th Dec., 1873.)

Among the many puzzling phenomena which glacialists have endeavoured to explain, not the least perplexing is the occurrence of loose erratics and perched blocks at considerably higher levels than the rock masses of which they once formed a part. Such erratics have been noted, not only in this country, but in glaciated regions elsewhere; perhaps the most remarkable examples being those which Scandinavian geologists have made known to us. Mr. Törnebohm, of the Geological Survey of Sweden, informed me that he had found blocks at a height of 4500 feet, which certainly could not have come from any place higher than 1800 feet. Mr. Darwin, many years ago, attempted to explain such anomalies in the glacial phenomena of our own country, by supposing that the erratics had been floated about on massive icebergs during a period of depression. He conceived that, as the land sank down, the bergs stranded or dropt their stony burdens at higher and higher levels of the drowning country. This ingenious explanation compels us, of course, to make one of two assumptions—namely, either that the movement of depression was rapidly effected, or that the icebergs were endowed with extraordinary longevity. Or, again, we might combine the two assumptions, and hold both that the downward movement was rapid, and that the

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icebergs took long years to melt away. I fear, however, that the theory is more ingenious than satisfactory. There are many considerations that militate against it, among which I shall only mention this, that we have no evidence of such a degree of submergence having obtained either in this country or in Scandinavia as would be necessary to account for the elevated position of many of the erratics in question. There are no doubt other objections to Mr. Darwin's explanation that will occur to a geologist familiar with the phenomena of glacial deposits in this country; but it is hardly necessary, at least for my present purpose, to specify the reasons that have led me to the belief that another explanation of the difficulty must be sought for.

The opinion held by Scandinavian geologists, and by many glacialists in this country, with whom I have conversed upon the subject, is that the erratics under review have been deposited in their present positions by land-ice. No one, however, has yet succeeded in showing how land-ice could have carried these large blocks from lower to higher levels. It is obviously impossible that the boulders could have travelled upon the surface of the ice in the usual way, nor is it credible that they could have been pushed on underneath along with the *moraine profonde* or till—for frequently they show no marks of abrasion or striation, but are in all respects similar to the large angular blocks that fringe the sides of Alpine glaciers.

Recent researches of my own having directed my attention more particularly to this curious problem, I am induced to believe that an explanation of the difficulty may eventually be found in certain phenomena which have been observed in Alpine glaciers. Among the late Principal Forbes' numerous letters on glaciers, addressed to Professor Jameson, there is one bearing date 12th December, 1846, in which some remarkable observations are recorded. I am not aware that the observations to which I am about to refer have ever been considered by geologists, nor do I know that any physicist has attempted another explanation of the phenomena than the one which seems to have satisfied Forbes. The phenomena in question relate to "the supposed tendency of glaciers to reject impurities, and the undoubted fact that stones are always found near or upon the surface of the ice." "It is strange," says Forbes, "that it should not have occurred to every one who sought to explain the appearance of stones on the surface by the *ablation* of the ice, that

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in order to arrive there at all, the blocks must previously have been embedded in the virgin ice, where popular belief, and, generally speaking, more accurate observations also, give them no place." Forbes then proceeds to give several examples of the phenomena, which I cannot do better than quote in his own words. Referring to the extruded stones on the Glacier du Nant Blanc, near Chamouni, he remarks that "the right bank of this glacier is at first bounded by rocky summits, but in the lower part of its course by a mound-like moraine of the usual form. The surface-blocks can only be derived from the precipices near the origin. Yet they do not even appear on the surface opposite the rocks, but only opposite to the moraine; and they increase in number and quantity towards the lower end of the glacier, where they almost blacken the surface of the right side, the left side remaining almost clean. It is difficult to believe that this accumulation is not due to the gradual denudation of the blocks by the melting of the ice in which they have been in some way or other embedded; but it is scarcely less difficult to admit that having fallen from the rocks above the *névé*, they should have remained unperceived in the ice during all the intermediate space.

"To take another example. The Glacier of the Rhone is distinguished by the extraordinary purity of its surface, and the consequent absence of lateral moraines. But this general freedom from stones on the surface is subject to one exception which is remarkable. *Stones begin to appear at the surface on the terminal slope at a considerable height.* How came they there? Not a stone the size of the fist can be seen on the surface farther up; and in examining a number of the crevasses I could not see any engorged in the ice. The explanation seems to be, that these stones are actually introduced into the ice by friction at the bottom of the glacier, and forced upwards by the action of the *frontal resistance* which produces the *frontal dip* of the veined structure, and they are finally dispersed on the surface by the melting of the ice."*

This explanation is of course bound up with the "viscous theory," and those who hold that the subsequent researches of Dr. Tyndall, and other physicists, have overturned Forbes' theory of the origin of the ribboned structure of glaciers, may be inclined to put these observations aside. But the facts recorded by Forbes

* *Edinburgh Philosophical Journal*, January, 1847.

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have an interest for geologists apart altogether from their bearing on the cause of glacier motion. Whether, as Forbes supposed, stones are carried upwards through the solid mass of a glacier by the filamentary sliding of the particles of ice—the curves of ejection corresponding exactly with those of forced separation—is a question for physicists to consider. It is enough for the geologist to know that stones apparently do travel upwards through the ice, nor will *ablation* alone suffice to explain the fact. If, for example, a boulder which has fallen into a crevasse and become embedded at a depth of 80 or 100 feet, should reappear upon the surface of the glacier at a point farther down the valley, it is evident that its reappearance at a relatively higher level in the glacier cannot be due to the melting of the ice alone. At one place it lies at 80 or 100 feet below the surface, but after the glacier has flowed for some distance, it reappears at the surface; that is to say, it seems to have risen 80 or 100 feet through the ice. If 80 or 100 feet of ice have been removed by melting and evaporation, then this loss has been again made good, but not by the accumulation of snow upon the surface of the glacier—the ice has been kept at its general level by the new supplies which are continually pouring into the valley at its origin. In other words, the ice in front rises just as fast as the ice advances from behind; it is thus that the general level of the glacier is maintained. Now the line of ejection along which the boulder has travelled cannot possibly dip at the same angle as the slope of the valley; for if that were the case, the boulder would always remain embedded in the ice, at the same distance from the underlying rock, until it was ejected at the terminal front of the glacier. But although the line of ejection must always dip at a less angle than the valley, yet it will in most cases still have a more or less perceptible dip in the same direction as the valley. A great deal will depend upon the boldness of the obstructions that impede the flow of the glacier. If these are numerous and formidable, then the lines of ejection will approximate more and more to the horizontal, and even at last curve upward, so as to dip *up* instead of *down* the valley; and thus boulders introduced into the ice at a given point will, as they are borne down the valley, not only rise as it were through the glacier, but eventually be extruded at a level which may be many feet, or even many yards, higher than the point in the valley from which they originally started.

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It seems to me that such must be the case, no matter what theory of glacier motion we hold. Forbes may be wrong in having maintained that the curves of ejection correspond with those of "forced separation," and his explanation of the veined structure may also be entirely wrong, although this can hardly be said to have been established, for not a few of the objections to his theory proceed upon the assumption that "the fracture and regelation theory" of glacier motion is demonstrably true. Tyndall has shown that the ribboned structure is due to pressure, and this may be freely admitted by those who may still cling to the "viscous theory." It remains to be proved, however, that there is no such filamentary sliding of the ice particles over each other as Forbes contended for. The experiments of the late Canon Moseley seem indeed to cut away the legs of both Forbes' and Tyndall's theories, but the molecular theory recently advanced by Mr. James Croll obviates Canon Moseley's difficulties, and may eventually show us that Forbes was not so far wrong when he insisted that there is a motion of the ice particles parallel to the direction of the blue veins in glaciers.

But however this may be, it is enough for me, as a geologist, to know that stones introduced into the body of a glacier, whether from above or below, tend to rise upwards in the ice, as the glacier flows on its way. And I now ask whether this fact does not throw some light on the curious problem which forms the subject of this communication? Let us picture to ourselves a mountainous country, such as Scotland or Scandinavia, covered with a wide ice-sheet, or series of confluent glaciers, and endeavour in imagination to follow the course of some hypothetical boulder which has become embedded in the ice. We shall conceive that this boulder has been introduced by friction into the ice at the bottom of some valley in the interior of the country. As the ice creeps outwards, the stone gradually rises, the path which it follows sloping at a less angle than the bed over which the ice flows. Did no obstruction intervene, it is evident that the boulder, while it rose through the body of the ice, would be at the same time travelling gradually to lower levels than the point from which it originally set out. And it is quite conceivable that under such circumstances a stone might rise as it were through a thickness of several thousand feet of glacier ice, and yet be eventually extruded at a lower level than the rock of which it once formed a part. But then we know that

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countless obstacles intervened to impede the flow of the massive ice-rivers of the Glacial Epoch; and with every such obstruction the glacier masses must have been forced to bulge upwards by the interse *vis a tergo*; and such upward movement of the ice, being again and again repeated, imprisoned boulders and debris would be compelled just as often to rise to higher and higher levels. Let us suppose that our hypothetical boulder is travelling in a nearly level course towards some ice-smothered hill. As the ice approaches this obstacle, it begins to bulge upwards, and our boulder is, as it were, forced up an inclined plane. Eventually, however, the ice sweeps round and overflows the obstacle, and thereafter continues on its course. There being now less longitudinal pressure, the included boulder will not rise so rapidly, but will travel either in a horizontal line, or down a gently-inclined plane. Let us suppose, further, that such obstructions to the flow of the ice supervene again and again, until at last the boulder is carried into some embayed recess of the ice-drowned country, such as one may see represented in miniature by sheltered hollows in the bed of a river. Now, in such a recess our boulder may linger for a considerable time, but as the ice is always melting and evaporating at the surface, and the loss thus caused is being continually made good by the advance of ice from behind, it is evident that unless the stratum of ice containing our boulder manages to creep out of the embayed recess as an "undertow," it will be forced to rise higher and higher until it becomes coalescent with that portion of the current which overflows all obstacles at a higher level. By this time our boulder, having travelled, let us say, 50 or 100 miles, may have been carried to a level many hundred feet or yards above that from which it originally started. We have now only further to conceive that, after a greater or less number of such vicissitudes, the boulder is at last extruded at the suface, and stranded on the side of some rocky hill that peers like an island above the surface of the far-stretching *mer de glace*.

Now, cases like this must have occurred again and again during the growth, continuance, and decay of the massive ice-sheet that once enveloped Scotland. We know from actual observation that just such obstacles as I have alluded to did really obstruct the flow of the Scotch ice. The confluent glaciers were frequently deflected, now to the right, now to the left, sometimes by opposing high grounds, at other times by masses of ice flowing in a different

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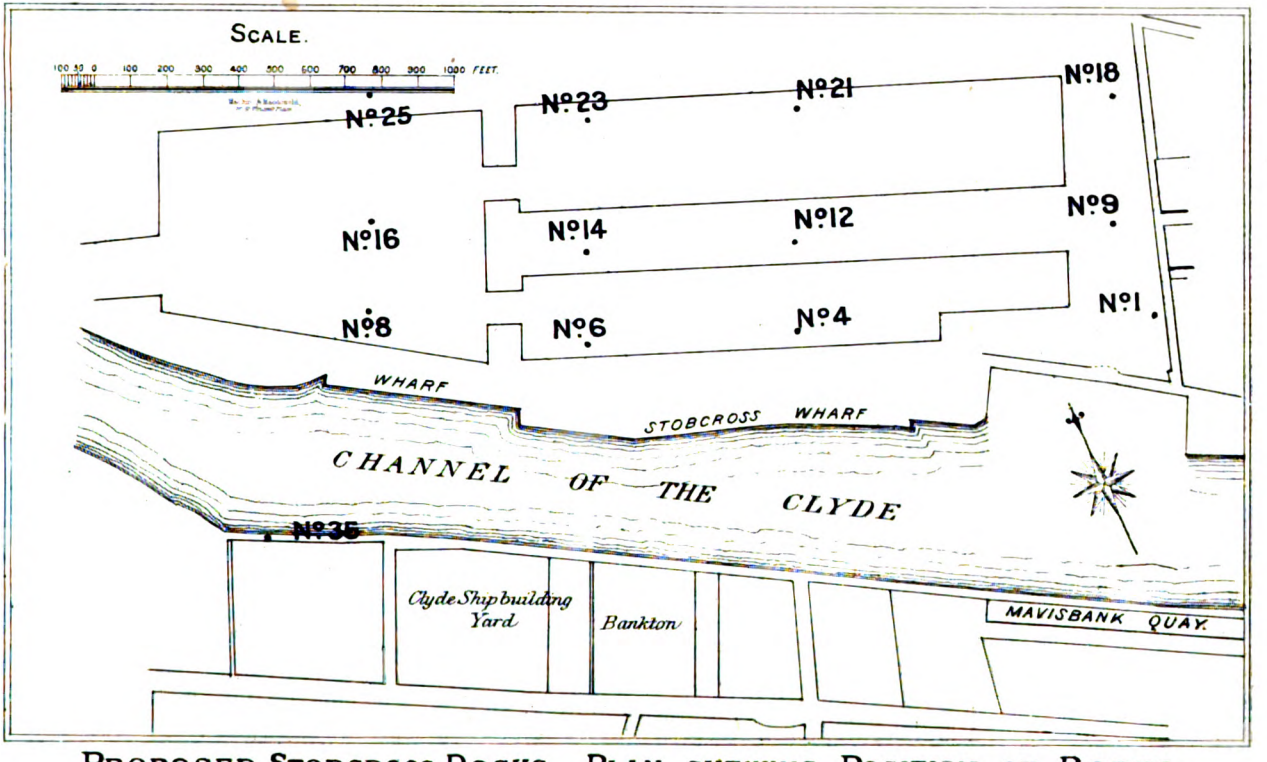

PROPOSED STOBCROSS DOCKS.— PLAN SHEWING POSITION OF BORES.

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direction. This we can read in the trend of *roches montonnées* and striae, in the dispersal of the stones in the till, and the distribution of loose erratics and perched blocks. Nay, we have even clear evidence to show that sometimes the under strata of the ice flowed in one direction, while the ice sweeping along at the surface followed a different route. Hence we can have no difficulty in admitting that such heaping up and bulging of the ice as is required to account for the transport of boulders from lower to higher levels must frequently have taken place in Scotland during the Glacial Epoch.

The generally non-glaciated aspect of the boulders in question is also perfectly accounted for on the theory I have ventured to advance. Once embedded in the ice, stones and boulders might travel for hundreds of miles without suffering abrasion. The well-known incident of the knapsack* which was lost in a crevasse of the Glacier du Talefre on 29th July, 1836, and disgorged by the coalescent Glacier du Lechaud on 24th July, 1846, after having travelled, embedded in the ice, over a distance of 4300 feet, shows how little change a hard lump of rock would sustain in travelling through a mass of glacier ice. Occasionally, however, such an included block might be rubbed against the rocks of a hill-side, and so receive a dressing on one or more faces.

I have thought it worth while to send this note to the Society, as it seems to me to give a feasible explanation of what has always hitherto appeared an insoluble difficulty. As I have remarked above, the acceptance of this explanation does not commit one to any particular theory of glacier motion. So far as it is concerned, all the theories may be wrong, or, what is perhaps more likely, there may be something of truth in each.

XX.—*On the* Post-Tertiary Fossiliferous Beds of Scotland.

By David Robertson, F.G.S., and the Rev. H. W. Crosskey, F.G.S.

(Continued from page 137).

XV.—JORDANHILL BRICKWORKS.

These works are situated fully a mile to the north-west of Partick, Glasgow, and extend on both sides of the Crow Road, 63 feet above the level of the sea. The works on the west side of the

* *Edinburgh Philosophical Journal*, January, 1847.

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road are named Woodend, and those on the east side Claythorn Brickworks. The clay is well seen in recent cuttings, extending on the west, also eastwardly, along the depressions on both sides of the Royal Lunatic Asylum, towards the Great Western Road. There can be little doubt that it is a continuation of the same clay which was lately exposed in sinking the foundations of Maryhill Gas Works, and in which fragments of mussel shells and Foraminifera *(Polystomella striato-punctata* and *Nonioninæ)* were found.

On the eastern side of Claythorn Works, the Whiteinch Railway cuts through an extension of the same clay, laying open a section about 800 yards in length. Under the bridge of the Crow Road, which crosses the railway, the clay is exposed to a depth of 14 feet. At the bottom it is dark-gray, with the common mussel embedded in considerable numbers. Immediately overlying the mussels, *Tellina calcarea* is met with, and some specimens present the two valves together.

About midway between the bridge and the east end of the section, the stiff stony boulder-clay comes on, and gradually rises to the height of a few feet; and from this point the laminated clay dips westerly and easterly along the cutting. For the greater length of the dip on the western side, the clay reaches the mould of the surface, but along the eastern side it is overlaid by gravelly sand to the depth of about 10 feet.

The same clays are seen in a cutting for the railway embankment along the hill-side towards Partick, and there can be little doubt that it is an extension of the same clay which is met with in the Stobcross Railway cutting; and we may also include the clays on the south side of the river as part of the same deposits, *e.g.* :—Windmill Croft, 10 feet above the level of the sea; Rowan Bridge, on the side of Paisley and Glasgow Canal, 46 feet; Muirhouse Brick Work, 57 feet; and Pollokshields, a little further to the west, at a still higher level.

There is one shell, the common mussel, *Mytilus edulis*, found in all these beds, and in all of them it is abundant. We may remark of this mollusc that it has been considered to have its zone or position near the surface, and to lie *above* the true types of the post-pliocene arctic shells in the clays of the Clyde district. This, no doubt, is frequently the case, but it is also found at greater depths and overlaid by arctic shells. At Paisley Brick Works the mussel is found 12 feet below the surface; at Jordanhill, 14 feet; at

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Muirhouse, 19 feet; and at Stobcross, 24 feet from the surface, leaving no doubt that it lived in common with the arctic shells throughout the whole period of these deposits in the valley of the Clyde.

The clay at Jordanhill is worked to the depth of twenty-two feet. Under one or two feet of surface-mould are seven or eight feet of reddish-brown clay, full of vertical fractures, whose sides have a bluish colour, and generally so smooth that they have much the appearance of "slickensides." Below this, the clay becomes dark gray, or what is generally called "blue clay," and is more compact than the overlying clays, till it reaches a bed which the workmen call mud, and which when dry is of a whitish colour and thinly laminated, and so friable that it is unfit for brick-making, unless mixed with other clays of a tougher character.

In passing, it may be noticed that on the east side, near the upper end of the Claythorn workings, beneath a bed containing arctic shells, the clay is greatly crowded with concretionary nodules, mostly of small size. These are of various shapes, but the greater number are flattened spheres, entirely smooth, with the exception of occasional small pebbles enclosed during formation. These nodules seem to be restricted to a space of a few yards in circumference. There is another small patch on the the same floor, of a reddish brown colour, and rough on the surface. These concretions are common in many of our clays, but it is unusual to find them in such profusion, and within so narrow limits as here, when they are almost entirely absent from the adjacent clays.

Another feature of the clays in this neighbourhood is the presence of portions of oak trees. One of these pieces, thirteen feet long and twenty inches in diameter, was met with in the clay at Woodend Works, at a depth of twelve feet. It lay horizontally, and had lost much of its roundness from decay, but was quite hard within. Another stump of oak, with about three feet exposed, and widening towards the bottom, was seen in an upright position, and reaching to within four feet of the surface in the railway cutting on the east side of the Royal Lunatic Asylum.

The deposit being marine, the upright position must be accidental. Other pieces of oak have been found in the brick works on the south side of the Great Western Road; and Mr. James Bennie informs us of the occurrence of such remains of vegetation in the laminated clays at Muirhouse, and at Gladstone Brick Works, near Bishopton.

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Still, oak trees, or portions of them, are of rather rare occurrence in the fossiliferous laminated clays of Scotland.

The clays of Jordanhill are not rich in shells or other animal remains, and such shells as do occur are generally not well preserved. This is more owing to erosion than to fracture or abrasion. On the west side of the road the shells are few, and chiefly mussels; but on the east side a number of different species, mostly arctic, are moderately common—particularly at the south-east corner of the works, where they are chiefly confined to a narrow band of two or three feet in thickness, which at some places is only about seven feet below the surface. Overlying this is a thin layer containing littoral shells, such as *Littorina littorea, Littorina obtusata, Littorina rudis,* and the young of *Mytilus edulis.**

AVIS.

Bones of a Bird.	Species undetermined.

CONCHIFERA.

Anomia ephippium, Linn.	Rare.
Mytilus edulis, Linn.	Moderately common.
Nucula tenuis, Mont.	Moderately common.
Leda pygmæa, Münst.	Moderately common.
Leda pernula, Müll.	Rather rare.
Cyprina Islandica, Linn.	Rather rare.
Tellina calcarea, Chemn.	Rather rare.
Mya truncata, Linn.	Rather rare and small.
Saxicava arctica, Linn.	Rare.

GASTEROPODA.

Trochus helicinus, Fabr.	Moderately rare.
,, *Grœnlandicus*, Chemn.	Rare.
Lacuna divaricata, Fabr.	Rare.
Littorina littorea, Linn.	Moderately common.
,, *rudis*, Maton.	Moderately common.
,, ,, var. Saxatilis.	Moderately rare.
,, *limata*, Loven.	Moderately common.
Rissoa striata, Adams.	Moderately rare.
,, *parva* var. *interrupta*.	Rather rare.
,, *inconspicua*, Ald.	Rather rare.

* A similar littoral bed is met with on the lower grounds on the north side of Paisley, about forty feet lower than at Jordanhill, thus showing two tidal belts that could not be coexistent. A sample of the clay at this place, containing the littoral shells, s found, when dry, to consist of—

66 per cent fine mud.
11 ,, ,, sand.
6 ,, coarse sand.
16 ,, gravel.

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Skenea planorbis, Fabr.	Rather rare.
Homalogyra atomus, Philip.	Rather rare.
Natica Grœnlandica, Beck.	Rather rare.
Purpura lapillus, Linn.	Rare.
Buccinum undatum, Linn.	Moderately rare.

POLYZOA.

CRUSTACEA.

Balanus crenatus, Brug.	Very common on the north side of the road at the north-east corner of the works.

ANNELIDA.

Spirorbis spirillum, Linn.	Moderately common.
Serpula vermicularis, Ellis.	Moderately rare.

FORAMINIFERA.

Biloculina depressa, D'Orb.	Rare.
,, *elongata*, D'Orb.	Rare.
Quinqueloculina seminulum, Linn.	Common.
,, ?	Moderately rare.
,, *subrotunda*, Mont.	Moderately rare.
Orbulina universa, D'Orb.	Rare.
Polystomella striato-punctata, Linn.	Common.
Nonionina asterizans, F. & M.	Common.

XVI.—STOBCROSS.

The cutting for the extension of the railway to the new docks at Stobcross exposed a section nearly half a mile in length, extending from Galbraith Street on the east to Sandyford Street on the west, and running nearly parallel to the Clyde, at a distance of about two hundred yards to the north of the river. This cutting was from thirty to forty feet in depth, and passed through boulder clay, sand, gravel, and laminated clay. It seemed also to coincide to some extent with a line of junction between two different deposits, as it exposed for a considerable distance a ridge of gravel on the south side, and beds of laminated sand and clay on the north. It thus presented to geologists an exceedingly favourable opportunity for studying the different beds brought to view in such close juxtaposition, and under circumstances so favourable for comparison.

At the west end of the cutting it passed through a knoll of boulder clay fully three hundred yards in length, and at a depth of

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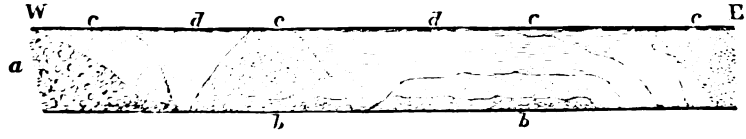
thirty-seven feet from its highest summit. By a bore put down by the Clyde Trustees, this hard stony unstratified clay was found to rest on 'blaize' at a depth of 104 feet from the surface of the ground. On the east, where the knoll dipped more rapidly than on the west, it was overlapped by a fine yellowish sand, which, after continuing a little further eastward, was replaced by gravel which was seen to extend to near the old house of Stobcross.



Section of Stobcross Railway Cutting—North side,
(Shewing the chief features, but not drawn to scale.)

a Boulder-clay.
b Gravel and sand.
c Sand.
d Laminated clay, with arctic shells.

This gravel does not appear to be a rewash from the boulder clay of the neighbourhood, as it contains a much greater proportion of schistoze white quartz, and a much smaller proportion of trap than we find in the boulder clay of the locality. When we consider the rolled, rounded, and smoothed state of the gravel, denuded of all striation, we are led to the conclusion that if it were a rewash of boulder clay, it must have come from some considerable distance. If the gravel were a rewash of underlying boulder clay, we would necessarily find the large boulders in the gravel that are so abundant in the boulder clay. But this is not the case. They are singularly absent from the gravel, and one larger than a man's head is rarely to be found in it. The agency that carried, and rolled, and smoothed the gravel, seems to have been incapable of transporting the larger blocks. If, then, the gravel is a rewash of boulder clay, we may presume that it is from a locality that will account for the greater preponderance of the schistoze rocks, and this cannot well be from the present tract of any part of the Clyde.

This gravel formed a connecting ridge with the boulder clay to the west, on which the sands and clays on the north side abutted and overlay. These beds of sand and clay were well exposed all along the north side of the cutting, the sand overlying the gravel, which again was overlaid by clay, and in some curves again by

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sand. But this must not be taken as a rule for the order of depo sition of the sands and gravels of the locality, as it appears from the Journal of Bores, that in many places the sand and gravel alternate, to the depth of between eighty and ninety feet below the datum line (or ten feet above high water).

These layers of sand, clay, and gravel did not maintain a horizontal line, or follow any regular dip, but presented at several points violent contortions and false bedding, and the overlying shell-bearing clays conformed to the undulations of the sand banks on which they were deposited.

The laminated clay for the most part was of a sandy character, and it was only near the eastern end that it became very pure and dark in the colour. At this point the clay was of great depth, and was overlapped from the east by muddy sand, which became less and less mixed with the clay as it receded from it.

Along the north face of the cutting, where the clay was seen overlying the lower sand, many of the layers of the sand were mixed with mud in a greater or less degree. The deposition of the mud seems to have gone on mixing with the sand till circumstances set in which allowed the former to accumulate.

On examining pieces of the clay made up of very thin layers, it was found that in most cases the divisions between the layers were formed by a very thin sprinkling of fine sand; and these layers were again divided into groups by thicker and coarser bands of sand. The groups of thin layers were sometimes of nearly uniform depth, but at other times were more irregular. The bands of sand also varied in their thickness. These very thin layers appear to have been formed by frequent gentle motions of the water, caused by winds or tides, carrying out over the mud only the finest particles of sand; and the thicker bands carried out by stronger winds and currents.

The relative time between the recurrence of these disturbing causes might be reckoned by the distance of the bands from one another, and the strength of such disturbances by the depth of the bands. We might further infer from the sharp lines between them that the causes were transient; but with such deposits as were seen at Stobcross, where the sand and clays had so much the appearance of having been washed and surged into each other, we should suppose that the conditions in such cases must have been more continuous, and probably in water comparatively shallow.

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The animal remains obtained from this section are chiefly from the deep cuts of clay near the east end, and although not numerous, they furnish sufficient proof of their purely marine and arctic character. This is all the more important as we found brackish water Ostracoda in the excavation for the new docks immediately adjoining. But as these occurred in beds of muddy sand close by the river, there is no doubt they are of much more recent date than the organisms now referred to.

CONCHIFERA.

Mytilus edulis, Linn.	This is the prevailing shell, but mostly crushed, and the broken valves bound together by indurated clay.
Cyprina Islandica, Linn.	Rare, half grown.
Tellina calcarea, Chemnitz.	Rare, rather small.
Mya truncata, Linn.	Rare.
Saxicava rugosa, Linn.	Rare, large.

GASTEROPODA.

Lacuna divaricata, Fabr.	Rare, small.
Littorina rudis, Maton.	Rare, small.
Rissoa Sp.?	Rare, greatly eroded.
Homalogyra atomus, Phil.	Rare.

POLYZOA.

Crisia eburnea, Linn.	Rather rare.
Membranipora Flemingii, Busk.	Rare.

CIRRIPEDIA.

Balanus crenatus, Brug.	Common.

OSTRACODA.

Ten Species.

FORAMINIFERA.

Quinqueloculina seminulum, Linn.	Rare.
,, *subrotunda*, Mont.	Rare.
Trochammina inflata, Mont.	Rare.
Lituola Canariensis, D'Orb.	Rare.
Discorbina globularis, D'Orb.	Rare.
Polystomella striato-punctata, F. & M.	Moderately common.
Nonionina asterizans, F. & M.	Moderately rare.
,, *umbilicatula*, Mont.	Rare.
,, *depressula*, W. & J.	Rare.

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For the Journal and Sketch Map of the Bores we are indebted to the kindness of Mr. James Deas, C.E., Clyde Trust.

The bores within the sketch plan show that the deposit is exceedingly variable both in composition and order of strata.

Although within an area of about 800 by 300 yards, there are not two bores in the twelve with the order of contents alike.

The rock is overlaid in six of the bores by gravel, and sand, and gravel; in two by coarse and fine sand; in two by clay; in other two by clay and stones (boulder clay). Three of the bores show gravel and sand alternating, of various depths, between the rock and surface soil, and one with clay and stones (boulder clay). Eight of the 12 bores have interstratified clay, or muddy clay, or muddy sand, of various thicknesses and at various depths.

Much of the clay in the railway section was seen bent into deep hollows or troughs. This was particularly the case at the eastern end of the cutting, where the clay bent steeply to the east. It is suggested by Mr. John Young, V.P. of this Society, that this might arise from the encroachment of the river on the sand banks, scooping out the sand from beneath the clays, and causing a falling in or bending down of the clays, as may still be seen in some parts of the river banks. This suggestion appears to be so far borne out by the crushed state of the mussel shells in the deposit, which we can easily conceive would be injured by any shifting of the material in which they were embedded. It may be remarked, however, that the same species is also found much crushed in the clays of Jordanhill Brickworks, where the shell deposit rests on stiff boulder clay, with little appearance of disturbance of any kind since the clays were first laid down.

Fig. 3 shows the irregularity of the rock surfaces, and that they are deepest on the line of bores 8, 6, 4, 1, nearest to the river, and stand higher 83 yards further back on the line 16, 14, 12, 9, and higher 133 yards still further back on the line 25, 23, 21, 18, except at 25, where the rock is only reached at a greater depth.

Bore No. 1.

	Ft.	In.	Ft.	In.
Ashes,	2	0		
Gravel,	0	9		
Brown sand,	14	0		
Gravel,	1	0		
Light sand,	5	0		
Brown sand,	35	3		
Gravel,	1	6		
Sand,	24	6		
Gravel,	1	0		
Sandstone,	2	0		
			87	0

Rock, 84·72 feet below surface.
,, 77·08 feet below high-water level.

Bore No. 4.

	Ft.	In.	Ft.	In.
Sand and ashes,	1	0		
Yellow clay,	5	0		
Light and dark sand,	4	0		
Gray Sand,	3	0		
Fine light sand,	12	0		
Yellow sand,	18	0		
Brown sand,	17	0		
Coarse sand,	7	6		
Gravel,	2	0		
Coarse sand,	3	0		
Sandstone,	2	6		
			75	0

Rock, 72·65 feet below surface.
,, 65·00 feet below high-water.

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Bore No. 4.

	Ft.	In.	Ft.	In.
Ashes,	1	4		
Soil,	1	8		
Muddy sand,	5	8		
Sand and gravel,	4	0		
Sand,	20	6		
Sand and gravel,	15	4		
Sand,	9	6		
Sand and gravel,	2	4		
Sand,	5	0		
Sand, clay, and stones,	5	4		
Sand and gravel,	2	4		
Sandy clay,	9	4		
Sandstone,	39	0		
			139	0

Rock, 78·72 feet below surface.
„ 70·22 feet below high-water.

Bore No. 8.

	Ft.	In.	Ft.	In.
Soil,	1	6		
Muddy sand,	6	6		
Sand and gravel,	68	0		
Coarse sandstone,	2	0		
			78	0

Rock, 75·71 feet below surface.
„ 67·81 feet below high-water.

Bore No. 9.

	Ft.	In.	Ft.	In.
Soil,	1	6		
Sand and clay,	7	6		
Gravel,	6	0		
Sand,	28	0		
Gravel and sand,	4	0		
Brown sand,	7	0		
Gravel,	1	6		
Sand,	1	6		
Gravel,	7	0		
Sand,	2	0		
Clay and stones,	17	0		
Sandstone,	2	0		
			85	0

Rock, 82·57 feet below surface.
„ 70·75 feet below high-water.

Bore No. 12.

	Ft.	In.	Ft.	In.
Soil,	2	0		
Gravel,	0	9		
Coarse sand,	8	0		
Sand and gravel,	9	6		
Coarse sandstone,	3	6		
Coarse brown sand,	11	0		
Fine brown sand,	29	9		
Sandstone,	2	0		
			66	6

Rock, 64·14 feet below surface.
„ 53·95 feet below high-water.

Bore No. 14.

	Ft.	In.	Ft.	In.
Soil and clay,	1	6		
Clay,	38	0		
Muddy clay,	13	0		
Sand,	16	0		
Gravel,	7	0		
Sand,	5	0		
Gravel,	2	0		
Sandstone,	2	0		
			75	6

Rock, 74·13 feet below surface.
„ 66·16 feet below high-water.

Bore No. 15.

	Ft.	In.	Ft.	In.
Soil,	2	0		
Sand,	2	0		
Sand and gravel,	8	0		
Brown sand,	24	0		
Light sand,	13	0		
Sand and gravel,	11	0		
Sand and gravel,	4			
Coarse sandstone,	8	6		
Soft gray sandstone,	4	0		
White sandstone,	11	6		
Sandstone with flakes,	6	6		
			160	0

Rock, 68·90 feet below surface.
„ 60·02 feet below high-water.

Bore No. 18.

	Ft.	In.	Ft.	In.
Soil,	0	6		
Gavel,	7	0		
Yellow sand,	20	0		
Muddy sand,	32	0		
Brown sand,	12	6		
Coarse brown sand,	8	0		
Sand and till,	10	0		
Sandstone,	17	0		
			107	0

Rock, 89·46 feet below surface.
„ 60·02 feet below high-water.

Bore No. 21.

	Ft.	In.	Ft.	In.
Soil,	1	0		
Sand and soil,	3	0		
Brown sand,	18	0		
Gravel,	7	0		
Brown sand,	24	0		
Sand and gravel,	2	6		
Gray sandstone,	35	0		
			90	6

Rock, 55·06 feet below surface.
„ 35·60 feet below high-water.

Bore No. 25.

	Ft.	In.	Ft.	In.
Soil and clay,	1	6		
Clay and stones,	102	6		
Dark blaize,	12	6		
			116	6

Rock not reached.

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Bore No. 23.

	Ft.	In.	Ft.	In.
Soil, sand, and gravel, -	2	0		
Coarse sand, - - -	3	0		
Sand and gravel, - -	7	6		
Sand, clay, and gravel, -	14	0		
Coarse gravel, - -	12	0		
Sand and gravel, - -	5	0		
Coarse gravel, - -	14	0		
Gray sandstone, - -	2	0		
			60	0

Rock, 57·47 feet below surface.
„ 35·72 feet below high-water.

Bore No. 35.

	Ft.	In.	Ft.	In.
Sand and stones, - -	4	0		
Sand and mud, - -	8	0		
Yellow sand, - - -	2	0		
Brown sand, - - -	29	0		
Gray Sand, - - -	36	6		
Soft brown sand, - -	13	0		
Sandstone, - - -	4	0		
			96	0

Rock, 92·00 feet below surface.
„ 88·23 feet below high-water.

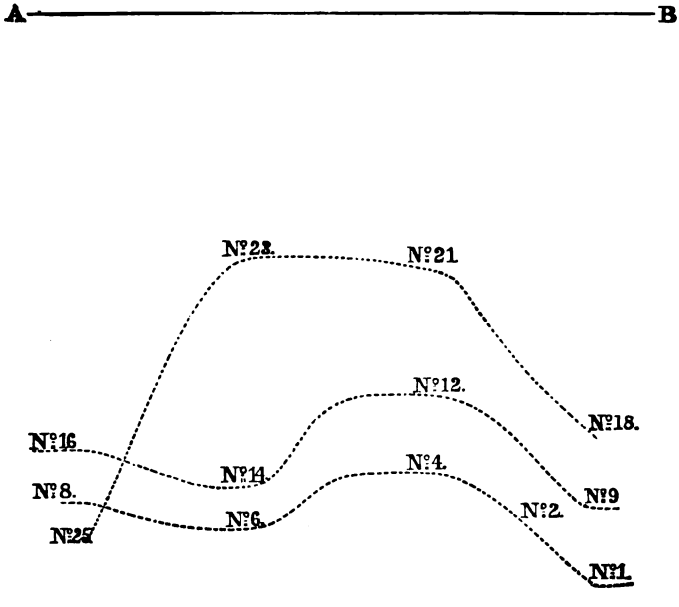

Figure 3.—Shewing the depths of the Bores from the level of ordinary high-water Spring-tides (A—B) to the surface of the rock.

XVII.—FAIRFIELD, NEAR GOVAN.

(Randolph, Elder, & Co.'s New Dock.)

In the cutting of this dock two different deposits were exposed. I. The first one was close to the river, consisting (*a*) of about four feet of sandy mould overlying one foot of black mud full of leaves, fragments of twigs, &c.; underneath this (*b*) were three to four feet of gravelly sand, which rested on muddy sand, of which only a

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foot or so was exposed. The layers of this part of the section were very irregular, and at some points much contorted.

In this muddy sand a few small valves of *Pecten opercularis* (Linn.), and *Trochus cinerarius* (Linn.), were obtained. Both of these shells are found living around our coasts, and subfossil in our old raised beaches; but not in any well authenticated cases are they associated with shells of arctic type. Along with these shells we found an Ostracod, *Loxoconcha elliptica* (Brady), which, remarkably enough, is a decidedly brackish-water form.

II. In the same section, about a dozen yards from the river, a different deposit of dark gray clay appeared. Unfortunately the progress of the dock was unexpectedly brought to a close ere the clay was much opened up, and the excavation soon filling with water, excluded all opportunity of seeing the mode of junction of the two deposits, and other particulars which we could have wished to obtain.

This dark gray clay dipped from the river for a distance of about eighty yards, when it began to incline upwards. At this point, at a depth of eighteen feet, marine shells were met with sparingly, *e.g.*, *Cyprina Islandica* (Linn.), *Mytilus edulis* (Linn.), and *Buccinum undatum* (Linn.) This last shell was partly covered by *Balanus crenatus* (Brug.) Although none of these shells proves decidedly the arctic character of the deposit, yet they are all common in the clay beds of the Clyde valley, which contains undoubted arctic species. Further, among the Ostracoda, *Cythere Montrosiense* (B. C. & R.) is moderately common, a species generally met with in the clays on the east of Scotland, which have been considered more intensely arctic than those on the west. We have no doubt that this deposit is of different age from that of the muddy sand close to the river, and that it belongs to the same series as the clays of Stobcross and Windmillcroft.

XVIII.—PAISLEY CANAL.

The discovery of marine shells in excavating the Glasgow and Paisley Canal was recorded in a paper read to the Wernerian Society, by Captain Laskey, so long ago as 1814.* This paper supplied the following list of species, all of which, according to the

* Memoirs of the Wernerian Society, Vol. IV., page 568.

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author, still inhabit the Frith of Clyde, but only below Dumbarton, where the water is constantly salt:—

Turbo littoreus = *Littorina littorea*, (Linn.)
,, *rudis* = ,, *rudis*, (Maton.)
,, *teretra* = *Turritella terebra* (Linn.)
Arca minuta = *Leda minuta* (Mül.)
,, *nuculus* = *Nucula nucleus* (Linn.)
Patella pellucida = *Helcion pellucidum* (Linn.)
,, *vulgaris* = *P. vulgata* (Linn.)
Buccinum lapillus = *Purpura lapillus* (Linn.)
Mytilus edulis.
Pecten opercularis.
Venus Islandica = *Cyprina Islandica* (Linn.)
Venus striata = *Venus gallina* (Linn.) ?
Venus literata = *Tapes pallustra* (Montagua.)
Balanus communis = *B. balanoides.*
Buccinum undatum.
Anomia ephippium.
Tellina plana = ? *calcarea*, or *Scrobicularia peperato.* ?
Cardium echinatum.
Natica litteralis.
,, *glaucina* = *Natica Alderi.* ?
Mya truncata.
Trochus crassus = *T. lineatus* (Da Costa.)

We are indebted for correction of the synonymy to Mr. Jeffreys, who says "that it is impossible to do more than guess at what is meant by *Venus striata*, *Tellina plana*, *Venus literata*, *Balanus communis*, and *Natica glaucina*."

The whole list is a puzzle, and it needs unusual faith in the author to believe that there is not some mistake. The group of shells is different from any thing we have in the clay beds in the west of Scotland; *Turritella terebra*, *Patella vulgata*, *Natica Alderi*, and *Trochus lineatus* are shells that we never find associated in any of our glacial deposits.

They would agree with those of our raised beaches, and were we quite satisfied that his *Tellina plana* was the *Tellina calcarea* of Chemnitz, we could not help suspecting that it was an interloper.

Some shells were recently found in cutting a drain on the north bank of the Canal, near Rowan Bridge, about two miles west of Glasgow, but we regret that we had no opportunity of procuring specimens to enable us to speak with any certanity of the character of the group.

An unexpected piece of evidence, however, has lately been

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afforded us on the subject. In the fine collection of minerals, &c., of the late Mr. Brown, of Langfine, presented to the Hunterian Museum, there are a few post-tertiary shells labelled "Glasgow and Paisley Canal, about one-half mile from Glasgow." This group is quite different from Laskey's list, and similar to the other glacial deposits of the Clyde district.

The species which we have identified are as follows:—

CONCHIFERA.	
Anomia ephippium, Linn.	Rare; fry.
Mytilus edulis, Linn.	Crushed, with indurated clay holding the valves together.
——— *modiolus*, Linn.	
Nucula.	
Leda pernula, Müll.	Moderately, in good condition.
Leda pygmæa, Münster.	
Cyprina Islandica, Linn.	In good condition.
Tellina calcarea, Chemn.	
Mya truncata, Linn.	Fry and large.
Saxicava rugosa, Linn.	
GASTEROPODA.	
Littorina littorea, Linn.	Large.
——— *obtusata*, Linn.	
——— *rudis*, Maton.	Rare.
Lacuna divaricata.	
Trophon truncatus, Ström.	
Buccinum undatum, Linn.	
Fusus antiquus.	
Natica affinis, Gmelin.	Common and large.
——— *Grœnlandica.*	
CIRRIPEDIA.	
Balanus crenatus.	
FORAMINIFERA.	
Biloculina ringens, Lamk.	Rare.
Quinqueloculina Gaultieriana, D'Orb.	Rare.
——— ——— *seminulum*, Linn.	Moderately common.
——— ——— *subrotunda*, Mont.	Moderately common.
Lagena squamosa var. *hexagona.*	Rare.
Orbulina universa, ? D'Orb.	Rare.
Discorbina globularis, D'Orb.	Rare.
Polystomella striato-punctata, F. & M.	Moderately common.
Nonionina depressula, W. & J.	Moderately common.

The clay is of a gray colour, and when dry consists of 89 per cent. fine mud; 11 per cent. debris of shells, and small gravel, and sand. The shell fragments are mostly the common mussel (*Mytilus edulis*) and *Balani*.

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XIX.—DIPPLE TILE-WORKS.

These works are situated about three miles to the east of the town of Girvan, in Ayrshire.* The deposit is remarkable for the character of its fauna, containing fresh-water, brackish, and marine forms in descending order. These are not mixed promiscuously together from top to bottom, but are mostly pure marine forms at the bottom, brackish in the middle, and fresh-water towards the top. We examined three samples of the clay from these different parts of the section.

(A.) The uppermost bed, between six and nine feet below the surface, is distinctly laminated, of a brownish colour, and mixed with black specks and streaks, giving the layers a dark, mottled appearance. When they are separated or laid open when dry, masses of fibrous substance are seen embedded in the clay in all directions, which, together with a few seed-like bodies, are doubtless of vegetable origin.

The animal remains at this depth are mostly of fresh-water character, such as a great abundance of the chitonous parts of the families *Daphniadæ* and *Lyncidæ*, together with various forms of *Cypridæ* and others, with more or less tendency to spread out into brackish water, such as *Limnocythere inopinata*, *Laxoconcha tamarindus*, and *Cythere tenera*. Along with these there are a few small fragments of shells, which appear to be of the common mussel; but at this depth of the section no purely marine forms are seen.

(B.) Under this, at a depth of nine to thirteen feet, the clay is of a uniform gray colour. At this part of the section there are a few fresh-water remains, as *Sphærium corneum* and *Cypris gibba;* but the brackish water forms greatly predominate, as *Cytheridea lacustris*, and *Cythere castanea*, the latter being very abundant; while the more decided marine character begins to appear in *Utriculus obtusus* and *Homalogyra atomus*.

(C.) At from thirteen to sixteen feet the fresh-water and brackish organisms have mostly disappeared. The shells here, although few belong to the larger species, are more numerous both in species and individuals than in any of the overlying beds. If we take them in their prevailing order, they are as on next page.

* We are indebted to Mr. Robert Gray, late Secretary to the Natural History Society of Glasgow, for introducing us to this deposit.

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Homalogyra atomus.	*Mya truncata*, fry.
Rissoa striata.	*Mytilus edulis*, fragments.
Utriculus obtusus.	*Balanus crenatus.*
Leda pygmæa.	Crab claw.
Axinus flexuosus.	A few fry of Gasteropods, very
Skenea planorbis.	small, undetermined.

There are about twenty-two species of Ostracoda from the three samples, most numerous in the lowest, with some few fresh and brackish water forms.

There are only seven species of Foraminifera found in the section from top to bottom, and what may seem strange is, that all these seven species are represented in the upper part of the section, that is, between six and nine feet from the surface—two of the seven species in the middle part of the section between nine and thirteen feet, and four in the lower part of the section between thirteen and sixteen feet from the surface.

In no part of the section were any of the species abundant; in the upper part six of the species were represented by one specimen each.

CONCHIFERA.

Mytilus edulis, Linn.	Rather rare.
Leda pygmæa, Münst.	Moderately common.
Axinus flexuosus, Mont.	Rare.
Mya truncata, Linn.	Rare, fry.
Sphærium corneum, Linn.	Common.

GASTEROPODA.

Rissoa striata, Adanis.	Moderately common.
Skenea planorbis, Fabr.	Rare.
Homalogyra atomus, Phil.	Common.
Utriculus obtusus, Mont.	Common.

OSTRACODA.

Twenty-two Species.

CIRRIPEDIA.

Balanus crenatus, Brug.	Rare.

ECHINODERMATA.

Spines, Sp. ?	A few small pieces.

FORAMINIFERA.

Quinqueloculina seminulum, Linn.	Rather rare.
——— *subrotunda*, Mont.	Rare.
Trochammina inflata, Mont.	Rare.
Lituola Canariensis, D'Orb.	Rare.
Polystomella striato-punctata, F. & M.	Moderately common.
Nonionina asterizans, F. & M.	Rare.
——— *depressula*, W. & J.	Moderately common.

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XXI.—Note *on the* Precipitation of Clay in Fresh and Salt Water. By David Robertson, F.G.S.

(Read 24th April, 1873.)

Among the many observations that have been made regarding the silting up of rivers as they approach the sea, and the formation of deltas at their mouths, there is one point that I have not seen noticed so distinctly as I think it deserves, viz.,—the effects which sea-water has upon clay suspended in fresh water when the two liquids meet. To ascertain the different actions of fresh and brackish water on suspended clay, a glass jar, twelve inches deep by two and a half wide, was filled with a fresh-water solution of clay. The water was from the Glasgow water supply. The mixture, when made up, was quite opaque. In twenty-four hours its appearance had undergone little change, further than that about an eighth of an inch at the surface had become so far free of impurity as to have the transparency of table beer. In thirteen days nearly half an inch had become still more transparent; the next two inches were paler, but could not be seen through. Eighteen days later the colour had begun to form into zones of different degrees of purity. At the top, fully an inch was transparent; the next two inches were opaque; the next three inches still more so; and from that to the bottom there appeared to be little or no change in the colour. These zones of colour did not graduate into each other, but continued well defined, following one another in gradual succession, each moving towards the bottom at its own rate of speed.

That particles of the clay of similar character keep together was seen from the precipitates being formed into bands of different colour. In this way the impurities of large sheets of water may form layers of different colours, and of different qualities, from the precipitation of the same mixture.

Time need not be taken up with a series of details, further than stating that the impurities gradually subsided, leaving the water by the end of six months comparatively clear, but still with a tinge of colour. This was more readily detected by two jars having been filled, one with a solution of reddish clay, and the other with a solution of dark gray clay. While both were tolerably clear at the end of the six months, yet the contrast of the one which contained the reddish clay, with its amber tint, and the

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other, which had the gray clay, with its whitish tinge, was at once apparent.

From this we may see how long and how far suspended clay may be carried into fresh water. But there are many agencies that accelerate the precipitation of clay in water. In a paper contributed by Mr. W. Skey, to the Wellington Philosophical Society, it is stated that the "substance having the greatest precipitating effect upon clay in water is sulphuric acid, one part of which is effective upon twenty-five thousand parts of the mixture. Generally, spring water is sufficiently charged with salts to effect the clarifying of clay water in twenty-four hours or so. A solution of magnesia, a substance which one would take to be quite inert, soon clarifies clay water, though it requires seven thousand parts to dissolve it." *

With clay dissolved in one part of fresh water, added to four parts of sea water, the mixture in one hour had become much lighter in colour; in two hours print could be read through the contents of the jar two and a half inches diameter; in four hours all the grosser matter had precipitated.

When the sea water was reduced to two parts in six of fresh water, the results were nearly the same—only a little slower.

From these experiments we see that water, only slightly brackish, has a great power of precipitating the clay, and the consequence must be, that the greater portion of the suspended clay carried down by rivers into the sea is precipitated before it can reach any great distance from the shore. It is true that the colour of the sea may be affected far beyond the *embouchure* of the river. It is stated, for example, that the discoloration of the sea by the water of the Amazon has been perceptible at a distance of three hundred miles. We can conceive that where such a body of water rolls onward, it will keep its own course clear for a considerable distance. The fresh water being lighter than the salt water, much of it will float on the surface for longer or shorter distances, according to its volume and speed.

Prof. Edward Forbes, when dredging in an arm of the sea at Killeries, Ireland, found that many of the marine animals were nearly lifeless when brought to the surface, which he ascribed to the stunning effects of an upper stratum of fresh water upon them, as they were brought up through it.

* *Proceedings of the Wellington Phil. Soc.*, Vol. IV., p. 381.

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Keeping in view the large quantities of earthy matter annually carried down by rivers, and that a large proportion of it is precipitated as soon as it comes into contact with the water of the sea, we can easily understand how the courses of rivers, within the influence of the tide, diverge into various branches by the precipitated mud silting up the river bed at one place, and the obstructed water forcing a new channel at another. The facts now recorded seem thus to throw a new light on the formation of deltas at the mouths of rivers.

XXII.—*On the* Probable Source *of* Certain Boulders *in the* Till *of the* Glasgow District. By John Young, V.P.

(Read 27th March, 1873.)

In the Till of the Glasgow district there occurs a greater variety of boulders than perhaps is to be met with in that of any other tract in the West of Scotland. These are of all sizes, varying from about four feet in diameter down to the smallest pebbles. It must be evident to any one who has closely examined the large assemblages of boulders taken out of the Till in the numerous cuttings around Glasgow during recent years, that the variety of rocks represented is such as could only have been collected or drawn together from a wide extent of country lying in several diverse directions. When a more intimate acquaintance with the various rock formations of the West of Scotland and with their mineral and fossil characteristics is obtained, it will doubtless enable us to indicate with greater precision and certainty the sources of many of these boulders from the Till, than we can at present do.

As the localities from whence many of the boulders seem to have been derived are quite independent, and often at variance with the direction of the striæ on the underlying rocks, an increased knowledge of the neighbouring rock formations would enable us the more clearly to point out the directions from which the ice-sheet moved that deposited the Till over the wide maritime valley of the Clyde. This promiscuous assemblage of boulders from various portions of the country, and found lying at all depths in

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the Till, clearly indicates to my mind that the boulder clay of the Glasgow district is a subsequent deposit laid down over former glaciated and submerged tracts from the melting of rubbish-laden ice that had moved seawards from higher levels of the country. In confirmation of this view, I have to direct the attention of the Society to specimens of various boulders, chiefly carboniferous, that have been found in the Till of this neighbourhood; and which, from their mineral and fossil characteristics, are apparently all from the Campsie district. They occur with other varieties of rocks that have evidently been derived from parts of the country lying to the west and north-west, while the bearing of Campsie is north and north-east of the tracts where they were found, and is also at nearly right-angles to the prevailing lines of glacial striæ in the district north of Glasgow; these being, with the exception of those at Possil, already recorded in the Society's Transactions, all in directions varying from north-west to south-west.

The boulders which I would here indicate, from their contained fossils and mineral composition, as being probably from the Campsie district, are, *first*, those belonging to, or corresponding with, the main limestone series. This limestone crops out all along the flanks of both the North and South hills at Campsie. It is of a gray colour, hard, and fine-grained in texture, being almost wholly composed of a very fine encrinal debris, with an occasional shell or two in the deposit. In one part of the district, stretching eastwards from Scullion gour to Glorat Limeworks on the North hill, there often lies over the main post of limestone an impure band known as the lid of the limestone. This stratum in some tracts contains a good many organisms, chiefly Brachiopoda, amongst which the following rare species are not uncommon, viz.:—*Camarophoria crumena*, Mart., *Strophomena rhomboidalis*, var. *analoga*, Phil., *Productus mesolobus*, Phil., *P. cora*, D'Orb., *P. aculeatus*, Mart., and *P. undatus*, Defrance. As this assemblage of rather rare forms is very seldom met with in any of our other limestones out of the Campsie district, it thus becomes comparatively easy to fix upon the locality where certain boulders found in the Till around Glasgow have been derived. Limestone boulders found in the Till of the railway cutting at Stobcross, for example, have yielded me numerous examples of the above species, besides the other characteristic organisims of this band. I have also found that well-glaciated boulders of the Campsie main limestone are moderately

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common in nearly all the cuttings of the Till in the Glasgow district, and that they occur equally abundant in that deposit, over rocks that have been glaciated from the north-west as well as from the north-east.

The other boulders of the Campsie limestone series, that I have frequently recognised in the Till, are from what is locally known as the "white limestone band." This is a stratum of limestone, apparently of fresh-water origin, that underlies the main coal of that locality, and which I have never observed *in situ* out of the Campsie district. It is of a light gray colour, compact and hard in texture, and is further characterised by the abundance of Entomostracans belonging to the genus *Cythere* which it contains, as well as by the presence of *Spirorbis carbonarius*. The finest series of these organisims that I have ever obtained were extracted from partially decomposed boulders of the limestone found in the Till of this district.

The other boulders of carboniferous rocks which I assign with a certain amount of probability to the Campsie district, consist of large nodules of fossiliferous clay ironstone that apparently belong to a stratum which lies in the South hill, and is found *in situ* in Craigenglen; and to a band of limestone found in the same hill at Barraston. The clay ironstone nodules are characterised by containing several well-known Craigenglen fossils, viz.:—*Productus latissimus*, Sow., *Trochus biserratus*, Phil., several species of *Aviculopecten*, and other shells, as well as by the presence of *Lithodendron fasciculatum*, Mart. This coral, and the above group of shells, I have never met with, nor seen, from any of the other clay ironstones of the West of Scotland, but they occur in carboniferous deposits in other tracts of our coalfield.

In my paper on the Geology of the Campsie District,* mention is made of a bed of limestone met with in the sinking of a pit at Barraston, on the South hill, which, from its mineral composition and contained fossils, differed much from any of the other Campsie limestones. Its position is 30 fathoms above the Hosie limestone of that district, and, as far as known to me, has not been observed anywhere else *in situ*. Boulders of this limestone have turned up in the Till at Stobcross, which I recognised at once by the abundance of its characteristic organism, a small branching polyzoon, *Ceriopora gracilis*, Phil. The colour of the limestone is

* Trans. Geol. Soc., Glas., Vol. I., Pt. 1, p. 40.

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a dark bluish-gray, and in weathered specimens shows a considerable amount of iron in its composition; the upper part of the bed often assuming the "cone in cone" structure.

There are numerous other boulders of our harder carboniferous rocks in the Till of the Glasgow district, some of which may also have been transported from the neighbourhood of Campsie; but as they do not present any mineral or fossil characteristics by which they could be identified with strata peculiar to that locality, the determination of the tract from which they were originally derived is more difficult. This remark applies to many of the local trap boulders, which agree in mineral composition with varieties found in the North hill at Campsie, but known also to extend beyond the bounds of that district. There is, however, one variety of trap which is limited to a comparatively small tract on the North hill at Campsie, which I have found in the Till at Stobcross, and on Gilmorehill. This is a boss of diorite in which the crystals of hornblende are very large and conspicuous, especially in weathered boulders. It occurs *in situ* on the hill-side, a little to the north-west of Sculliongour Limestone Quarries, and is apparently intrusive amongst the carboniferous strata and bedded traps of the hill. Boulders of this peculiar diorite, known only to occur at this spot in the extended range of the Campsie hills, are found strewn all along the valley of Campsie for miles to the eastward, but I have never found them to the west of where the rock is seen *in situ*. The two places just mentioned, Stobcross and Gilmorehill, are the only localities where I have observed boulders of this diorite in the Glasgow district. Their presence in these tracts, along with other boulders of Campsie rocks, clearly indicates that ice moving from north and north-east sources had carried forward from that neighbourhood a certain proportion of the boulders and other materials forming the Till of the Clyde valley.

The heights from whence the above boulders seem to have been derived vary from 300 to 400 feet above the sea level, and the tracts in which they lay in the Till would be from 20 to 100 feet above the Clyde at Glasgow. If they came from northern sources, as I am inclined to believe they did, then they could only have been carried forward to their present positions by ice moving from that direction; and the evidence that ice did flow from these points, subsequent to the general north-western glaciation of the district, is clearly recorded on the sandstone rocks at Possil

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already referred to, and on a tract once seen by me at Bishopbriggs quarries in former years, but now quarried away.

As the boulder clay, however, of the Glasgow district is evidently a deposit *more recent* than either of the above glaciations, and contains rocks, as now pointed out, from widely-divergent localities, and lying at all levels in the Till, the theory that ascribes its accumulation to the agency of floating ice, that had travelled from higher and various districts of country, is the only one which appears to me fully to explain all the facts of the case, and to accord best with its intimate composition and the diversified character of its boulders. I have already, in a former paper to this Society,* given a few reasons for believing that the Till of the lower valleys of Scotland could not have been deposited under a sheet of land ice while it lay above the sea level, nor as long as it clung to the land after entering the sea; and since that paper was read I have seen nothing to alter, but much to confirm, the views then expressed as to what I think were the conditions under which the boulder clay was deposited.

XXIII.—*On the Occurrence of* SACCAMMINA CARTERI (Brady) *in the Limestone Series of the Lanarkshire Coalfield.* By JOHN YOUNG, V.P.

(Read, 10th April, 1872.)

THE organism which forms the subject of the following remarks was found, as far back as the year 1864, while on an excursion in the Carluke district, in company with Messrs. Armstrong and Thomson. On that occasion we were conducted to several interesting fossil-bearing localities by our corresponding member, J. S. Hunter, Esq., of Daleville, Carluke. Amongst the places visited was a recent opening, a short distance to the south-east of Braidwood Railway Station, where a quantity of limestone and light-coloured felspathic trap was exposed. In masses of the limestone we noticed an abundance of small spherical spots of white carbonate of lime embedded in the dark gray matrix, which gave to the stone a peculiar mottled appearance, somewhat like that observed in limestone, in which cross sections of the corals *Syringopora* and *Lithodendron junceum* are shown; but as these spheres

* Trans. Geol. Soc., Glas., Vol. III., Pt. 2, p. 305.

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did not show any apparent organic structure to the naked eye, we concluded at the time that they had probably been superinduced in the limestone by being in contact with the bed of white trap above referred to, and which had indurated the rock to a considerable extent.

Shortly after the above-mentioned excursion, I received from Dr. Rankin, Carluke—who is alive to every thing of geological interest that turns up in his district—a small chip of the limestone, with an inquiry if I could say what the spheres of carbonate of lime had been. I was not then able to give him any information beyond the conclusion formerly arrived at, and I added that I did not think they were of organic origin. I was at this time the more inclined to hold this view, as I had previously found under the beds of trap at Murray's Hall Limeworks, near Stirling, a bed of highly-indurated carboniferous shale, filled with numerous small spheres of iron pyrites, which had clearly been formed in the rock by the heat of the overlying trap; the rock somewhat resembling in structure that of the limestone from Braidwood. Specimens of both these rocks I had collected for the Hunterian Museum series, as illustrations of curious structure superinduced in sedimentary strata by the action of trap, and since the above period the limestone has remained in the collection without further investigation, as I did not know of any organism to which the enclosed spheres could be referred.

In 1872 Mr. James Thomson, F.G.S., presented to the Hunterian Museum a small piece of rock from the "four-fathom limestone" of the Elf Hills, in Northumberland, which contained, in relief, on its weathered surface, numerous small spherical and pyriform bodies, which had previously been described in an interesting paper in the "Annals and Magazine of Natural History," for March, 1871, by Henry B. Brady, F.L.S., Newcastle-on-Tyne, as a new Foraminifer, under the name of *Saccammina Carteri*. On examining the fractured spheres in Mr. Thomson's Elf Hill specimen, I was struck with their general resemblance to those in the limestone from Braidwood, Carluke, and concluded that they, in all probability, belonged to the same organism. In this conjecture I was confirmed by Mr. Brady, to whom I sent some chips of the limestone for examination. None of the Braidwood limestone shows the spheres in relief on the stone, like that from the Elf Hills; but this is owing, no doubt, to the rock not

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having been exposed to weathering influences. The Braidwood limestone, however, shows the spheres in the matrix much more distinctly than that from the Elf Hills. In the latter, the spheres are filled with a grayish-coloured infiltration of silica and carbonate of lime, which causes them to be less conspicuous.

Mr. Brady, in the paper referred to, describes *Saccammina Carteri* "as spherical, or rather fusiform bodies, whose average size is about $\frac{1}{8}$ inch in length, and $\frac{1}{12}$ inch in transverse diameter—the two ends being usually produced and tubular, apparently for the passage of sarcode stolons or pseudopodia. They are sometimes symmetrical, but more frequently one end tapers more gradually than the other. Occasionally the base is rounded, and the shape is completely pyriform." In the Braidwood limestone I find them of the same general form and size as above described; but only in one section have I as yet seen an example in which two of the spheres are connected by their stoloniferous tube, all the others occurring as single bodies. This feature, however, may arise, as stated by Mr. Brady, from the fracturing in many instances of the slender intermediate processes. Having prepared several transparent sections of the Braidwood limestone, I find enclosed in the matrix numerous spheres, filled, or partially filled, with the dark-coloured sediment of the stone, while portions of the thin tests of other broken spheres occur in abundance. Owing to the absence of any infiltrations of silica into the spheres, sections of the rock are very easily prepared. These show the form and structure of the organisms so clearly that there cannot be the least doubt of their complete identity with those described by Mr. Brady from the Elf Hills.

I am indebted to Dr. Rankin for the information regarding the geological position of the bed containing the *Saccammina Carteri*. He informs me that it is the second "calmy" limestone of his section, and that it lies in the lower limestone series of the Lanarkshire coalfield. So far as I am aware, the above organism has not yet been detected in any other locality in the West of Scotland, and I bring it before the Society as an important addition to our list of carboniferous fossils, which, but for the very interesting discovery of Mr. Brady, as to its foraminiferal character, might yet have been lying in our collections unrecognised and undetermined.

Prior to the discovery of *Saccammina Carteri* in the "four-fathom limestone" in the Elf Hills, similar organisms, as stated

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by Mr. Brady, had been met with in the examination of mineral veins and the adjacent rocks by Mr. Charles Moore, F.G.S., Bath. These had been submitted for examination to Mr. Brady, who says—"When first investigated, the characters of the fossil seemed sufficiently distinct from those of any known type of Foraminifera to necessitate the establishment of a new genus for its reception, and the generic term *Carteria** was provisionally assigned to it; but I have since had the opportunity of seeing a number of type slides of deep Atlantic Foraminifera sent by Prof. Sars, of Christiania, to Dr. Carpenter, and amongst them specimens of his *Saccammina sphærica*, a species named in his paper on the deep-sea fauna, † but, so far as I know, not yet described. I am further indebted to Dr. Carpenter for a supply of specimens of this form, which appears to be common at great depths, and careful examination has convinced me of its very close relationship to the carboniferous fossil, although sufficient difference appears to exist in minor particulars to justify specific separation."

The foregoing quotation from Mr. Brady's paper is of interest, as showing that *Saccammina Carteri* of our carboniferous rocks is represented at the present time in the deep Atlantic sea-bottom by a closely-allied living species, which, no doubt, is descended from the older form, although no trace of the genus has yet been detected in any strata of intermediate age between the carboniferous and recent seas.

NOTE.—Since the above remarks were communicated to the Society, Mr. Robert Etheridge, Junr., F.G.S., in a short paper to the Geological Society of Edinburgh, *Transactions*, Vol. II., Part 2, 1873, refers to the occurrence of *Saccammina Carteri* in the limestones of the East of Scotland, and in the Explanation to Sheet Twenty-three of the Geological Survey of Scotland, he gives the following localities for the fossil, viz.,—Mount Lothian, Fullerton, Baads Mill, Magazine, Crichton, No. 16 Mine, Addiewell; Currielee and Middleton limestone quarries, Edinburghshire, at which places it was discovered by the survey collector, Mr. James Bennie, corresponding member of this Society. Mr. Etheridge also states that it has been obtained from the limestone at Cat Craig, Dunbar. To this list we have to add the locality at Braidwood, as stated in the foregoing paper, and its further discovery by Mr. Hunter, in the main limestone of that district, making altogether ten different localities in which the organism has already been detected in Scotland.

* See *Brit. Assoc. Reports*, 1869 (Exeter Meeting), p. 381. "I had hoped (says Mr. Brady) to associate the *type* with the name of my friend H. J. Carter, F.R.S., who has laboured so assiduously and successfully amongst the Protozoa. As the matter stands, the specific term only is left at my disposal."

† See *Vidensk. Selsk. Forhandlinger*, for 1868, p. 248.

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XXIV.—*The* Fossils *of the* Carboniferous Strata *of the* West of Scotland. By John Young, *Vice-President*, and James Armstrong, formerly *Honorary Secretary*.

(Read 13th March, 1873.)

INTRODUCTION.

In the introductory remarks to our General Catalogue of the Carboniferous Fossils of the West of Scotland,* we pointed out the desirability of having lists prepared of the fossils found in each particular group of strata in the various localities where they occur, for the sake of comparison with similar lists from the same geological horizons at other places, stating that "it is only when stratigraphical lists of our fossils are prepared on some such exhaustive plan, that we will ever be able to arrive at anything like a correct notion of the alternate changes of condition under which the flora and fauna of the Carboniferous period existed, as indicated by its beds of terrestrial, fresh water, and marine strata."

Our distinguished honorary member, Thomas Davidson, Esq., F.R.S., in a paper recently communicated to the Edinburgh Geological Society,† also urges upon its members the necessity of preparing local catalogues, such as those above indicated, and he points out the immense importance of Palæontology to Geology, mentioning one or two instances out of numbers which he could adduce, to show where the correct determination of a few fossils has been the means of unravelling the age and position of strata, not only in Britain, but in distant regions of the globe.

In making out these catalogues, therefore, we will endeavour, with the assistance of members of the Society, to give from time to time, in the Transactions, a record of the fossils found in the strata of a particular locality, so far as known, and we trust that when these are completed, they will help to show where a species is apparently confined to a particular stratum and locality, or is recurrent throughout a series of beds extending over wide tracts of the earth's surface.

* Trans. Geol. Soc. of Glas., Vol. III., Supplement, 1871.

† Trans. Edin. Geol. Soc., Vol. II., p. 184, 1873.

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It is our intention to give figures and descriptions of several new species contained in our cabinets, as well as to figure some of the rarer forms, and those also of which imperfect representations are given in the works of other palæontologists.

No. I. ROBROYSTON.

Robroyston, the district from which we give the first special catalogue, is historically known as the locality where Sir William Wallace was betrayed into the hands of the English, in August, 1305. It lies about three miles to the north-east of Glasgow, and near the summit of that undulating tract of country which separates the valley of the Clyde on the south from that of the Kelvin on the north. Robroyston may be reached from Glasgow, either by the Garngad and Provan Mill Road, or by train to Bishopbriggs, and thence eastward by the village of Auchenairn. The limestone beds formerly worked there are termed the "Robroyston Limestone Series," but are known by other local names in its various outcrops, both north and south of the Clyde. It is what is termed a "calm" limestone, being of fine, compact texture, and bluish-grey colour when newly broken, but changing into a yellowish-grey on exposure, from the presence of iron. In this district the limestone averages from five to six feet in thickness, and is parted into two beds by a thin layer of shale. It is not very rich in fossils, the organisms being chiefly confined to a few species of Brachiopods and Cephalopods, with an occasional Crinoid stem, etc. But the bed of shale lying immediately over the limestone has yielded a considerable number of species, as will be seen from the list. A few feet under the limestone there is found a bed of coal of varying quality and thickness. It gradually thins along its southern outcrop in this district to a foot or less, while to the north it thickens considerably, and is found in the Kirkintilloch and Campsie districts to be seven and five feet respectively.

The limestone at Robroyston was formerly worked in open-cast quarries on the farms of Hillhead, Barmulloch, and at other places in the neighbourhood. From the old shale heaps at these deserted quarries, specimens of the fossils may still be collected, while, by washing and carefully examining the weathered shale, abundance of the smaller organisms may be obtained.

Occasionally the limestone and shales are passed through in the pits put down to the Possil upper black-band ironstone worked

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in the neighbourhood, and at these places the fossils characteristic of the strata may be obtained when these pits are being sunk. The Robroyston limestone is overlapped to the eastward by a series of sandstones and shales, stated to be the representatives of the millstone grit, this limestone being made the line of division in the new map of the district prepared by the Geological Survey, between that group and the upper limestone series of this portion of the Lanarkshire coalfield. The equivalent of the Robroyston limestone has long been extensively worked in the neighbouring districts of Garnkirk, Chryston, Bedlay, and Moodiesburn, chiefly as a flux for iron-smelting. It has also been passed through in pits in the parishes of Campsie, Kirkintilloch, and Cumbernauld. On the eastern border of the Lanarkshire coalfield it is found at various places in the Carluke district, having been worked at Gare and Westerhouse in former years. From these places large and interesting collections of the fossils found in the shale have been made, which agree very closely in genera and species with those found at Robroyston. South of the Clyde it is worked in the district around Thornliebank, Pollokshaws, and Barrhead, in open-cast quarries. Its equivalent is also found at Limekilnburn, south-west of Hamilton, as well as in other districts in and around the borders of our Western coalfield, where, perhaps, it has not yet been so correctly identified, owing to local changes in the composition of the strata, and slight variations in the group of fossils.

As formerly stated, the fossils are chiefly contained in the overlying shale, which is of a light grey colour at its junction with the limestone, but gradually changes as it passes upwards into a dark grey shale, in which they are much less abundant. The great majority of the larger species exist in a broken, fragmentary, or crushed condition, as is commonly the case in the soft limestone shales of most localities; still, perfect examples of many of them have been obtained, while all have the original shell-structure very well preserved.

None of the comparatively few species found in the limestone are known to be different from those in the shale. It will, however, be seen from the list, that the number of species inhabiting this part of the old Carboniferous sea-bottom had very much increased in both genera and species by the time when the overlying shale was deposited. From the greater absence of Corals and Polyzoa in the Robroyston limestone and shales, than in

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many of the other Scottish limestone strata, it would seem that the beds were laid down in water of very moderate depth, and that the conditions were not so favourable for the growth and development of these classes as in the formation of some of our other limestones. The structure and composition of the limestone also show that it could not be a very deep-sea deposit, a considerable per centage of clay having been mixed with the lime during deposition, while the comparatively few fossils met with in the stone clearly proves that the stratum was not built up by the growth and decay of organisms, like some of our richly-fossiliferous limestones, it being, like many of our other "calm" or "cement" limestones, formed to a large extent from the chemical precipitation of lime in the sea water—these, likewise, containing very few fossils.

The underlying coal-bed indicates that land conditions must have prevailed to a large extent over the Lanarkshire coalfield, prior to the deposition of the limestone; and the intermediate strata, from its fossils, seem to point to fresh or brackish water conditions having obtained during the interval when the coal-bed was being gradually depressed, and the period when the intervening strata were finally covered by the sea.

The following sections of a pit sunk to the coal under the Robroyston limestone at Balquarhage, near Campsie, will show the relation of the various strata more clearly than any now to be obtained at Robroyston old quarries.

	Feet.	Inches.
Surface soil and boulder clay, ...	7	0
Dark grey shale, with a few marine shells, ...	42	0
Light grey shale, with numerous shells, Trilobites, Crinoidea, etc., ...	3	0
Light grey shale, passing gradually into limestone, with fewer fossils, ...	1	0
Calm limestone in two beds, parted by layer of grey shale; fossils rather rare, ...	8	0
Grey calcareous shale, passing upwards into limestone, with very few fossils, ...	1	0
Bituminous shale, with a few obscure plant remains, ...	2	0
Dark bluish-grey shale; no fossils observed, ...	2	0
Grey shale, with large round nodules of clay ironstone; no fossils observed, ...	2	0
Dark grey soft shale; no fossils observed, ...	1	0
Black semi-bituminous, with small ironstone nodules (doggars); no fossils observed, ...	1	

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	Feet.	Inches.
Bituminous oil shale, with scales of small ganoid fishes and obscure plant remains, ...	0	6
Coal inferior in quality at this place; of better quality in pits to the south-east, ...	5	0
Dark grey sandy shale, with *Stigmaria* and other coal plants, not passed through, ...	3	0
	79	0

NOTE.—Under the above beds in this locality are known to occur a thick group of sandstones and shales, with one or two beds of marine limestone. These have been also passed through in the pits at Robroyston, in sinking to the Possil ironstones. The average thickness of this series of upper carboniferous limestone strata varies from 80 to 100 fathoms, in different portions of the Lanarkshire coalfield. But none of the limestone beds attains a greater thickness than six or eight feet, while many are much thinner. Except in the limestone bands, fossils are very rare throughout the other members of the group; those that have been met with are generally fragmentary remains of plants and fishes, scattered through the sandstones and shales. These are of types that indicate land, fresh, and brackish water conditions, the widely-separated limestones with their overlying shales being the only strata which from their fossils present us with periods when true marine conditions prevailed.

FORAMINIFERA.

1. ENDOTHYRA RADIATA, *Brady.*

   Rare. In the shale.

2. TROCHAMMINA CENTRIFUGA, *Brady.*

   Abundant in the shale at Barmulloch and Hillhead. These are the only localities where this species has been found so plentiful, and in such a well-preserved condition.

3. T. INCERTA, *D'Orb.*

   Moderately common in the shale.

4. VALVULINA PALÆOTROCHUS, *Ehrenberg.*

   Rare. In the shale.

Note.—We are indebted to Mr. H. B. Brady, F.L.S., for his kind determination of the species of Foraminifera.

ZOOPHYTA.

1. ALVEOLITES SEPTOSA, *Flem.*

   Rare. Limestone and shale.

2. HETEROPHYLLIA MIRABILIS, *Dunc.*

   Very rare. One or two fragments in the shale.

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3. LITHOSTROTION JUNCEUM, *Flem.*

Very rare. In the shale.

4. PALÆACIS (ASTRÆOPORA) CYCLOSTOMA, *Phil.*

Very rare. In the shale on crinoid stems.

5. STENOPORA TUMIDA, *Phil.*

Very rare. In the shale.

6. ZAPHRENTIS PHILLIPSI, *M. Edw.*

Common. In the shale.

7. Z. SPINULOSA, *M. Edw.*

Very rare. In the shale.

ECHINODERMATA.

1. ARCHÆOCIDARIS URII, *Flem.*

Rare. Fragments of spines, plates, and dental apparatus in the shale.

2. A. ——————, *Sp.*

Fragments of small, slender spines, finely striated, and minutely tuberculated, of apparently an undescribed species, are moderately common in the shale.

3. ACTINOCRINUS ——————, *Sp.*

Fragments of stems, and portions of the calices of several species not uncommon in the limestone and shale.

4. PISOCRINUS GLOBULARIS, *De Kon.*

Rare. Portions of the calyx in the shale.

[In our General Catalogue, p. 21, the generic name is given as *Hydreionocrinus*, but we have since been informed by Prof. de Koninck, that it should be *Pisocrinus*, as the former name was an error of his printer.]

5. PLATYCRINUS ——————, *Sp.*

Fragments of the stems, and plates of the calyx of several species referable to this genus, occur in the limestone and shale.

6. POTERIOCRINUS CRASSUS, *Miller.*

Common. Stems and portions of the calyx abundant in the shale; more rare in the limestone.

7. P. ——————, *Sp.*

Fragments of other species not uncommon in the shale.

8. RHODOCRINUS UNIARTICULATUS, *De Kon.*

Very rare. Fragment of the calyx in the shale.

9. R. ——————, *Sp.*

Fragments referable to other species in the shale.

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ANNELIDA.

1. ORTONIA CARBONARIA, *J. Young.* Geol. Mag., Vol. X., p. 112.
   Rare. In the shale; attached, or showing where it had been attached to the spines of *Productus*, etc.
2. SERPULA CAPERATUS, *M'Coy.*
   Very rare. In the shale.
3. SERPULITES CARBONARIUS, *M'Coy.*
   Very rare. In the shale.
4. S. MEMBRANACEUS, *M'Coy.*
   Very rare. In the shale.
5. VERMILIA MINUTA, *Brown.*
   Very rare. On crinoid stems in the shale.

CRUSTACEA.

1. BAIRDIA CURTA, *var.* PLEBEIA, *Jones* and *Kirkby.*
   Rare. This and the following species of Entomostraca are obtained from the shale.
2. B. SUBMUCRONATA, *Jones* and *Kirkby.*
   Rare.
3. BEYRICHIA BITUBERCULATA, *M'Coy.*
   Rare.
4. B. RADIATA, *Jones* and *Kirkby.*
   Rare.
5. CYPRIDINA PHILLIPSIANA, *Jones* and *Kirkby.*
   Very rare.
6. CYTHERE CORNIGERA, *Jones* and *Kirkby.*
   Rare.
7. C. CUNEOLA, *Jones* and *Kirkby.*
   Common.
8. C. FABULINA, *var.*, *Jones* and *Kirkby.*
   Common.
9. C. VENTRICORNIS, *Jones* and *Kirkby.*
   Rare.
10. KIRKBYA PERMIANA, *Jones.*
    Very rare.

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11. K. URII, *Jones.*

Rare.

12. LEPERDITIA OKENI, *Mün.*

Rare.

13. YOUNGIA RECTIDORSALIS, *Jones* and *Kirkby.* MS.

Common.

14. GIFFITHIDES MESOTUBERCULATUS, *M'Coy.*

Rare. Fragments of this Trilobite occur in the shale.

POLYZOA.

1. ARCHÆOPORA NEXILIS, *De Kon.*

Rare. In the shale, attached to crinoid stems.

2. CARINELLA CELLULIFERA, *R. Etheridge, jun.* Geol. Mag., Vol. X., pl. xv.

Moderately common in the shale. Found also at Gare, in the Carluke district. Fragments of this and the following species of Polyzoa are found in the shale. They are, however, neither so abundant nor so well preserved as in the limestone shales of some other localities in the West of Scotland.

3. CERIOPORA INTERPOROSA, *Phil.*

Rare.

4. FENESTELLA MULTIPORATA, *M'Coy.*

Rare.

5. F. OCULATA, *M'Coy.*

Rare.

6. GLAUCONOME BIPINNATA, *Phil.*

Rare.

7. G. STELLIPORA, *Sp. nov., Dr. Young* and *J. Young.* MS.

Fragments of one or two other species, apparently undescribed, in the shale.

8. PALÆOCORYNE SCOTICUM, *Dunc.* and *Jenk.*

Rather rare. Specimens of the Hydrocaulus in the shale.

We place this fossil in this group, and not in *Hydrozoa*, as we believe it to be Polyzoan processes.

9. POLYPORA VERRUCOSA, (?) *M'Coy.*

Moderately common.

10. RHABDOMESON GRACILE, *Phil. sp. Gen. nov., Dr. Young* and *J. Young.* Ann. and Mag. of Nat. Hist., May, 1874, p. 335.

Rare. This and the following species were formerly referred to *Ceriopora.*

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11. R. RHOMBIFERA, *Phil.*

Rare.

12. SULCORETEPORA PARALLELA, *Phil.*

Rare.

13. SYNOCLADIA BISERIALIS, *var.* CARBONARIA, *R. Etheridge, jun.* Geol. Surv. of Scotland. Explanation to Sheet 23, p. 102.

BRACHIOPODA.

1. ATHYRIS AMBIGUA, *Sow.*

Rare. Perfect examples in the limestone, fragments in the shale.

2. CHONETES LAGUESSIANA, *De Kon.* C. HARDRENSIS, in Gen. Cat.

Rare in the limestone, common in the shale, and in good preservation. At this locality this shell does not attain the same large size as those found in the High Blantyre and East Kilbride shales.

Note.—Professor de Koninck is satisfied that this species and C. HARDRENSIS are identical. See *Mon. des Fossilles Carbonifères de Bleiberg en Carinthie*, p 41. Bruxelles, 1873.

3. CRANIA QUADRATA, *M'Coy.*

Very rare. In the shale, on crinoid stems, &c.

4. DISCINA NITIDA, *Phil.*

Rare. In the shale.

5. L. MYTILOIDES, *Sow.*

Rare. In the shale.

6. LINGULA SCOTICA, *Dav.*

Very rare. A single imperfect example in the shale.

7. ORTHIS MICHELINI, *Lev.*

Rare. In the shale.

8. O. RESUPINATA, *Mart.*

Common. Found in crushed fragments, and perfect small examples in the shale; rare in the limestone.

9. PRODUCTUS LATISSIMUS, *J. de C. Sow.*

Rare. Limestone and shale.

10. P. LONGISPINUS, *Sow.*

Rare. In the shale.

11. P. SCABRICULUS, *Mart.*

Rare. Perfect examples in limestone and shale.

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12. P. SEMIRETICULATUS, *Mart.*

Moderately common in the limestone; the var. *P. Martini*, found in perfect and crushed examples in the shale.

13. RHYNCHONELLA PUGNUS, *Mart.*

Rare. Well preserved examples of a depressed variety of this shell in the shale.

14. SPIRIFERA LINEATA, *Mart.*

Rare. In the limestone; perfect examples.

15. S. TRIGONALIS, *Mart.*

Moderately common in the limestone. Perfect small examples of var. *S. bisulcatus* in the shale.

16. S. URII, *Flem.*

Very rare. A single valve in the shale.

17. SPIRIFERINA CRISTATA, *var.* OCTOPLICATA, *Sow.*

Rare. Crushed fragments in the shale.

18. STREPTORHYNCHUS CRENISTRIA, *Phil.*

Rare. Fragments in the limestone and shale.

19. STROPHOMENA ANALOGA, *var.* DISTORTA, *J. de C. Sow.*

Rare. Portions of detached valves in the shale.

20. TEREBRATULA HASTATA, *Sow.*

Rare. Perfect examples in the limestone.

LAMELLIBRANCHIATA.

1. AVICULOPECTEN FIMBRIATUS, *Phil.*

Very rare. A single valve in ironstone nodule.

2. A. INTERSTITIALIS, *Phil.*

Very rare. Single valves in shale.

3. A. SIMPLEX, *De Kon.*

Very rare. Single valve in ironstone nodule.

4. ARCA LACORDAIRIANA, *De Kon.*

Rare. Perfect and crushed examples in the shale.

5. AXINUS (SCHIZODUS) DELTOIDEUS, *Phil.*

Rare. Casts in the shale.

6. CARDIOMORPHA PUZOZIANA, *De Kon.*

Rare. In the shale.

7. CYPRICARDIA ACUTICARINATA, *Armstrong.*

Rare. Perfect examples in the shale.

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8. C. CREBRICOSTATA, *Armstrong.*

Very rare. A single perfect example in the shale.

9. EDMONDIA GIBBOSA, *M'Coy.*

Rare. Crushed and perfect specimens in the shale.

10. LEDA ATTENUATUM, *Flem.*

Rare. Some specimens attain a larger size than any we have observed from any other locality. Small examples found in the shale agree in form with M'Coy's figures of *L. birostrata*, and *L. leiorhyncha*, which are probably founded on small and variable examples of *L. attenuatum.*

11. L. CLAVATA, *M'Coy.*

Rare. In the shale.

12. L. INTERMEDIA, *R. Etheridge, jun.* Geol. Mag., Vol. X., p. 347, pl. xii., fig. 3.

Not common. In the shale.

13. NUCULA GIBBOSA, *Flem.*

Rare. In the shale; crushed and perfect examples.

14. N. LINEATA, *Phil.*

Common. Perfect small examples in the shale.

15. N. ——— *Sp.*

Rare. In the shale.

16. SANGUINOLITES IRIDINOIDES, *M'Coy.*

Very rare. A fragment in the shale.

PTEROPODA.

1. CONULARIA QUADRISULCATA, *M'Coy.*

Rare. Fragments, an inch or more in length, occasionally found in the shale; one example only with the aperture in tolerable preservation.

GASTEROPODA.

1. CHITON HUMILIS, *Kirkby.*

A single perfect posterior plate in the shale.

2. CHITON, *Sp.*

Very rare. Fragments of apparently two other species in the shale.

3. DENTALIUM INORNATUM, *M'Coy.*

Very rare. In the shale.

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4. ELENCHUS SUBULATUS, *M'Coy.*

Rare. Small specimens agreeing closely with this species, and showing the tooth on the pillar lip found in the shale.

5. EULIMA PHILLIPSIANA, *De Kon.*

Very rare. One or two specimens in the shale.

6. *LOXONEMA CLATHRATULA, *Sp. nov.*

Desc. *Elongate, composed of from seven to eight whorls, regularly convex, and separated by a moderately deep suture; surface ornamented with fine, close, spiral ridges, intersected by slightly arched costæ, also fine, but very distinct, both sets covering the entire whorls from base to apex; aperture slightly imperfect in our specimens, but it appears to be the same as in the other Loxonema. Length, two lines; diameter of body-whorl, two-thirds line.*

Obs. The prominent convexity of the whorls, together with the sharp intersecting costulæ, distinguish this beautiful little shell from the other species of the genus. It occurs also at Orchard, near Pollokshaws, in shale. At Robroyston it is rare, and is found usually among the shale washings.

7. L. CURVILINEA, *Phil.*

Common. Perfect examples in the shale. This shell appears to be rare in most other localities.

8. L. SCALAROIDEA, *Phil.*

Common. Perfect examples in the shale.

9. MACROCHEILUS ACUTUS, *Sow.*

Common. Perfect small specimens in the shale.

10. M. FUSIFORMIS, *Sow.*

Rare. Small specimens in the shale.

11. M. MICHOTIANUS, *De Kon.*

Rare. One or two perfect in the shale

12. M. SEMISTRIATUS, *Sp. nov.*

Desc. *Acutely conical; spire composed of from five to six moderately-rounded whorls; body-whorl, two-thirds the length of the shell, smooth; other whorls distinctly marked with numerous close-set and slightly-arched transverse striæ; mouth imperfect, apparently the same as in other species of the genus. Length, four lines; width of body-whorl, two and a half lines.*

Obs. This little shell approaches closely in form to that of *M. acutus*, found in the same bed, but is at once distinguished from that species by its distinctly striated spire, and smooth body-whorl. Young specimens have the whole shell striated.

Rare. In the shale. Found also in the shale at Orchard.

* Figures of this and other new and rare species will be given on Plate I., to accompany our next paper, which will be on the Fossils of the Orchard Cement limestone.

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13. MURCHISONIA FIMBRICARINATA, *Sp. nov.*

Desc. *Elongate, conical; spire of eight slightly-angular and gradually-increasing whorls; suture moderately deep; surface marked with three spiral grooves, between which there are two fimbriated, or ribbed bands, the upper or that nearest the apex of the shell being broadest, most distinctly marked, and placed nearly on the centre of the whorls. Mouth imperfect. Length, three and a half lines; width of last whorl, one and a half lines.*

Obs. This species is distinguished from others of the genus by the fimbriated ornamentation of its spiral bands.

Rare. One example in the shale.

14. M. STRIATULA, *De Kon.*

Rare. A few examples only found in the shale.

15. NATICOPSIS ROBROYSTONENSIS, *Sp. nov.*

Desc. *Subglobose; spire composed of four to five convex whorls, with a blunt termination, the last occupying fully two-thirds of the total length of the shell, bulging considerably, and bending round gradually towards the columella without losing its fulness; suture very distinct and slightly channelled between the outer and penultimate volution; aperture, long-oval; columella bent inwards and flattened; surface covered with prominent, close, semi-arcuated costulæ. Height, one and a half lines; width of body-whorl, two lines.*

Obs. This beautiful little *Naticopsis* occurs at South Hill, Campsie, in a bed of shale overlying the Hosie limestone (lower limestone series), along with *Goniatites, Nucula, Spirifera Urii*, etc., and in the upper limestone series at Orchard. At these localities it is very rare, and it is only at Robroyston that it is found in considerable numbers.

Professor de Koninck, to whom we submitted specimens, considered this shell to be quite distinct from any other *Naticopsis* within his extensive experience, and we have his authority for describing it as a new species.

16. PLEUROTOMARIA BENEDIANA, *De Kon.*

Rare. A few examples in the shale.

17. P. CARINATA, *Sow.*

Very rare. A single crushed example in the shale.

18. P. CONTRARIA, *De Kon.*

Rare. Small specimens in the shale.

19. P. FRENOYANA, *De Kon.*

Rare. One or two tolerably perfect specimens in the shale.

20. P. MONILIFERA, *Phil.*

Common. Perfect specimens in the shale.

21. P. STRIATA, *Sow.*

Very rare. One or two in the shale.

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22. PLATYCERAS VETUSTUS, *Sow.*

Rare. Small examples in the shale.

23. BELLEROPHON DECUSSATUS, *Flem.*

Rare. In the shale.

24. B. DUCHASTELLI, *Lev.*

Rare. One or two specimens in the shale.

25. B. LEVEILLEANUS, *De Kon.*

Rare. In the shale.

26. B. URII, *Flem.*

Common. Small and full grown; perfect specimens in the shale; casts in the limestone.

CEPHALOPODA.

1. ACTINOCERAS GIGANTEUM, *Sow.*

Rare. Specimens several inches in length in the limestone; crushed fragments of the shell in the shale.

2. CYRTOCERAS GESNERI, *Martin.*

Very rare. One or two fragments in the shale.

3. C. UNGUIS, *Phil.*

Rare. Fragments in the shale.

4. GONIATITES EXCAVATUS, *Phil.*

Rare. In the shale.

5. G. IMPLICATUS, *Phil.*

Very rare. Single specimen, imperfect, in the shale.

6. G. MUTABILIS, *Phil.*

Rare. In the shale.

7. G. PAUCILOBUS, *Phil.*

Very rare. One or two examples from the shale.

8. G. STRIOLATUS, *Phil.*

Very rare. One example in ironstone nodule in the shale.

9. G. VESICA, *Phil.*

Very rare. One or two examples from the shale.

10. NAUTILUS INGENS, *Mart.*

Very rare. Casts in the limestone; fragments in the shale.

11. N. NODIFEROUS, *Armstrong.*

Rare. Fragments in the shale.

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12. N. QUADRATUS, *Flem.*

Rare. Fragments in the shale.

13. ORTHOCERAS ATTENUATUM, *Flem.*

Common. Well-preserved fragments in the shale.

14. O. SUBCENTRALE, *De Kon.*

Rare. Fragments in the shale.

15. O. UNDATUM, *Flem.*

Common. Well-preserved fragments in the shale.

PISCES.

1. PETRODUS PATELLIFORMIS, *M'Coy.*

One example only found in the shale.

2. RHIZODOPSIS GRANULATUS, *Ag.*

Rare. Found in ironstone; nodules in the shale.

Note.—The species in the foregoing list are contained in our own cabinets, and in those of Mr. James Thomson, F.G.S., Mr. vid Robertson, F.G.S., and Mr. James Neilson.

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XXV.—*On some* SECTIONS *of* CARBONIFEROUS LIMESTONE, *near* BUSBY. By JAMES NEILSON, Jun.

(Read 12th December, 1872.)

THESE sections are situated about seven miles south of Glasgow, a little to the north-east of the Eaglesham Road Station, on the Busby and East Kilbride Railway, and at a height of from five to six hundred feet above the level of the sea.

At this place we are near the south-western edge of the Lanarkshire coalfield, and a good idea may be formed of its transverse extent by ascending any of the hills in the district; as, for instance, that to the east of Thornton farm-house. In the distance to the west we descry the Bowling hills and the range of mountains from Ben Voirlich to Ben Ledi, while on the north the Clyde basin is bounded by the trap hills of Campsie and Kilsyth. A corresponding range of trap hills runs behind us on the south. The strata here dip under all the intermediate strata and reappear near the base of the Campsie hills, as we shall afterwards have occasion to notice. Between these points the strata are overlaid by part of the lower limestones, the middle ironstones, and the upper limestones, as well as by strata corresponding to the millstone grit, and the whole, or nearly the whole, of the upper coal measures.

The surface of the ground is of an undulating character, rising gradually towards the south. The sections to be described occur at four quarries, viz.,—Thornton, Thornton Hall, Braehead, and Phillipshill—the first being on the southern, the second on the western, and the third and fourth on the northern slope of one of the little ridges that extend along the district.

These quarries all work the same strata of limestone; but, owing to denudation, a full section is only to be seen at Thornton, where the section is something like the following:—

Boulder Clay,	from 4 to 24 feet 0 inches.
Calcareous Shale,	6 inches to 10 ,, 0 ,,
Hosie Limestone,	2 ,, 6 ,,
Fire Clay,	1 ,, 0 ,,
Impure Limestone,	2 ,, 0 ,,
Volcanic Ash,	3 ,, 0 ,,
Bituminous Shale,	1 ,, 0 ,,
Ironstone,	0 ,, 7 ,,

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Green Shale,	from 1½ to 0 feet 6 inches.
Ironstone,	0 ,, 6 ,,
Shale,	0 ,, 3 ,,
Ironstone,	0 ,, 6 ,,
Shale, with Entomostraca and fish remains,	0 ,, 1 ,,
Soft Black Shale,	0 ,, 8 ,,
"Three-post" Limestone,	3 ,, 0 ,,
Shale with Nodules,	from 1 to 0 ,, 6 ,,
Main Limestone,	7 ,, 0 ,,
Black Calcareous Shale,	2 ,, 6 ,,
Grey Shale.	

The boulder clay is of the usual stiff character, and of a brown colour. The boulders are mostly local, but a few from more distant regions are also to be found. For about 10 feet at the top the clay is not nearly so close and stiff as it is below that point. Possibly this is owing to the action of the weather. It does not, however, gradually become stiffer, but is seen to alter pretty sharply, and is taken off by the quarrymen in two cuts, counting from this division.

At Thornton the boulder clay rests on the uppermost shale given in the foregoing section. It may also be seen in the other quarries resting on the various beds from that down to the "three-post" limestone. At Thornton Hall this limestone is seen to be beautifully polished and striated, the striæ generally running in the direction N.E. and S.W., but in some parts of the quarry they have been observed to run N.W. and S.E.

The strata at all these localities lie nearly horizontal. There are no dikes to be seen, and any faults are very slight. The only volcanic rocks are the interstratified ash beds.

The highest shale seen in section at the quarries contains many well-preserved fossils. When first we visited it, being under very favourable circumstances, many fine and rare specimens were obtained, among which may be mentioned nearly a dozen *Goniatites*, about the same number of *Leda longirostris*, and *Nautilus subsulcatus*, besides specimens of *Euomphalus tuberculatus*, and others.

On comparing the group of fossils with that of the list from the Hosie limestone series on the south hill of Campsie, given by Mr. John Young, in his paper on the Geology of the Campsie district,* there can be no doubt that the beds are on the same geological horizon, many of the fossils being alike in both, and one

* Transactions of the Society, Vol. I., Pt. 1.

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large Entomostracan (*Polycope Youngiana*) being, so far as hitherto observed, confined to this same series of beds.

The locality on the south hill of Campsie was long a favourite one with our local geologists; and in the admirable Catalogue of Carboniferous Fossils of the West of Scotland, by Messrs. Young and Armstrong,* it is mentioned with an expression of regret that the shale heaps are now obliterated, and directions are given to look for future pit-sinkings along the south hill. At that time the authors did not expect it to appear about 15 miles to the southward.

Many of the fossils in this shale are converted into iron pyrites, and have a very fine appearance, especially when first laid open. This change does not seem to have taken place indiscriminately, or by chance, but according to species. Some species seem to have had a peculiar affinity during fossilisation to this sulphide, while with others this is wanting. Thus, *Goniatites*, *Pleurotomaria*, and others, are without exception more or less pyritised, while we have not seen an example of *Leda longirostris*, *L. attenuata*, or *Nucula gibbosa*, altered in this manner. Our chemical friends may, perhaps, be able to ascertain the cause of this difference; but we might suggest that it may be owing to some peculiarity in the composition of the shell.

This bed also contains a large number of curiously-shaped nodules, having an oolitic structure on the outside, although no trace of that structure is discernible when the nodules are broken up. At a certain stage of weathering, this shale forms into hexagonal prisms about half an inch across. We are aware that many other shales do likewise weather in the same manner, but have not seen any in which the lines were so regular and well marked.

The distance between the Hosie and Main limestones at Campsie is about 22 fathoms, and at Carluke 19 fathoms; and from the fact that there are three or four ironstones wrought under the Hosie limestone at Campsie, we are of opinion that the missing strata here should be between the lowest ironstone and the "three-post" limestone.

The beds of impure limestone and volcanic ash in the section are of some interest. They are of a greenish colour, and are penetrated in numerous directions by rootlets of *Stigmaria*, which pass rom the one bed to the other. The limestone has probably been

* Trans., Vol. III. (Supplement).

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formed by chemical segregation. With the exception of the calcareous matter in the upper bed, they correspond in their general volcanic character.

The bituminous shale underlying this position contains many scattered fish scales and bones, and has received the name of "the fish bed."

With respect to the three bands of ironstone, Mr. Alex. S. Wilson has kindly favoured me with the following analysis and note:—

	No 1, Top.	No. 2, Middle.	No. 3, Bottom.
Protoxide of Iron,	27·77	16·97	15·43
Persulphide of Iron,	1·23	·59	·23
Protoxide of Manganese,	1·42	4·98	2·12
Lime,	2·08	5·37	28·89
Magnesia,	2·01	·76	1·51
Phosphoric Anhydride,	2·43	traces	traces
Carbonic Anhydride,	16·74	6·00	24·22
Alumina, &c.,	11·52	7·97	8·57
Silica,	19·20	55·12	17·56
Organic matter,	14·80	1·32	·75
Water,	·80	·92	·72
	100·00	100·00	100·00
Specific Gravity,	2·500	2·875	2·720

Remarks.—"No. 1, which contains a good deal of coaly matter, is a black-band ironstone of inferior quality, and owing to the large amount of phosphoric acid which it contains, is practically useless. No. 2 is not worth the working, and No. 3 could only be used as a limestone to facilitate the reduction of richer ores. The remarkable thing about these stones, however, is that there is not sufficient carbonic acid to combine with the earthy basis, some of which must consequently exist in combination with silicic acid. This fact utterly precludes their employment in the manufacture of pig iron."

The shale underlying the lowest of these ironstones is principally composed of the carapace valves of one or two species of Entomostraca, which, from their great abundance, resemble, to a certain extent, some of the Entomostracan shales of the West Calder coal-field. In Thornton this shale is calcareous, owing to the great abundance of these organisms, but at Braehead it partakes more of the character of an oil shale.

The limestone is chiefly wrought for the reduction of iron, although some is used for building purposes. The upper limestone contains one or two species of *Lithodendron*, and specimens may be obtained polished by the ice where the rock is glaciated. The

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"shale with nodules," between the limestones, is of the same character as that seen at some of the Beith quarries, and contains a few fossils.

The black shale under the limestones is only exposed when drains are made to carry off the water from the workings. It is literally charged with fossils, which are, however, mostly crushed. This bed presents a complete contrast to that over the Hosie limestone in the same section. It contains, say, ten specimens for every one in the other bed; but if good specimens are wanted, the ratio must be reversed. Crinoidea and Brachiopoda are common; Aviculopectens, common; other Lamellibranchiata, rare; while Cephalopoda and Gasteropoda are very rare. In the upper bed the proportions of the fossils in the various classes would have to be reversed. This bed contains good specimens of the interior of various species of *Productus*. I have not seen it cut through, and the information regarding its thickness, as well as relating to the grey shale, I obtained from the foreman of one of the quarries.

The following list of fossils is mostly made up from my own collection. I have to acknowledge assistance received from Mr. John Young and Mr. Jas. Armstrong in the correct identification of a number of the species:—

PLANTÆ.

Calamites nodosus, Schlot.	Rare. Volcanic ash beds and ironstone.
Lepidodendron selaginoides, Sternb.	Rare. Do. do.
Lycopodites, Sp. (showing structure).	Shale over Hosie limestone.
Stigmaria ficoides, Brong.	Common. Volcanic ash-beds and ironstone.
Trigonocarpon, Sp.	Very rare. Shale over Hosie limestone.

ZOOPHYTA.

Lithodendron irregulare, Phil.	Common. Three-post limestone.
——— *junceum*, Flem.	Common. Three-post limestone, and shale with nodules.
Stenopora tumida, Phil.	Rare. Shale over Hosie limestone; common in shale under main limestone.
Zaphrentis Phillipsi, M. Edw.	Common. Shale over Hosie limestone.
Cyathophyllum, Sp.	Rare. Do. do.

ECHINODERMATA.

Actinocrinus, Sp.	Rare. Shale over Hosie limestone.
Pisocrinus globularis, de Kon.	Common. Shale under main limestone.
Archæocidaris Urii, Flem.	Rare. Shale over Hosie limestone, and shale under main limestone.
Platycrinus trigintidactylus, Austin.	Rare. Shale under main limestone.
Poteriocrinus crassus, Miller.	Common. Do. do.

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ANNELIDA.

Serpulites carbonarius, M'Coy.	Rare. Shale over Hosie limestone.
——— *membranaceus*, M'Coy.	Rare. Do. do.

CRUSTACEA.

Bairdia brevis, J. and K.	Rare. Shale over Hosie limestone.
——— *curta*, var. *plebeia*, J. and K.	Do. do.
——— *cylindrica*, Mont.	Do. do.
Cythere, Sp.	Do. do.
Polycope Youngiana, J. and K.	Moderately common. do.
Leperditia Okeni, var. *Scoto-Burdigalensis*, Münster.	Forms a thin band of shale.
Leperditia, Sp.	In do. do.
Dithyrocaris testudineus, Scouler.	Very rare. Shale over Hosie limestone.
Griffithides, Sp.	Do. Do. do.

POLYZOA.

Ceriopora interporosa, Phil.	Rare. Shale under main limestone.
Fenestella plebeia, M'Coy.	Do. Do. do.
Polypora, Sp.	Do. Do. do.
Sulcoretepora parallela, Phil.	Do. Do. do.

BRACHIOPODA.

Athyris ambigua, Sow.	Very rare. Shale over Hosie limestone; common, shale with nodules.
——— *Royssii*, Lev.	Do. do. do.
Chonetes Laguessiana, de Kon.	Common. Shale under main limestone.
——— var. (Davidson, Scottish Brachiopoda, T. II. f. 7).	Rare. In shale over the Hosie limestone.
Chonetes polita, M'Coy.	Very rare. Shale over Hosie limestone; shale under main limestone.
Discina nitida, Phil.	Rare. Shale over Hosie limestone.
Lingula mytiloides, Sow.	Rare. Do. do.
Orthis Michelini, Lev.	Common. Shale with nodules.
———*resupinata*, Mart.	Do. Shale under main limestone.
Productus giganteus, Mart.	Do. Limestone.
——— *longispinus*, Sow.	Do. Shale over Hosie limestone; Shale under main limestone; in which interiors of the dorsal valve, showing the muscular impressions, are common.
——— *semireticulatus*, Mart.	Rare. Shale under main post.
——— var. *Martini*, Sow.	Do. Do. do.
Productus Youngianus, Dav.	Very rare. Shale over Hosie limestone.

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Rhynchonella pleurodon, Phil.	Rare. Shale with nodules.
——— *pugnus*, Mart.	Rare. Shale under main limestone.
Spirifera glabra, Mart.	Common at one position in shale over Hosie limestone; rare in the limestone.
——— *lineata*, Mart.	Common. Shale under main limestone.
——— *trigonalis*, Mart.	Moderately common. do.
——— var. *bisulcata*, Sow.	Do. do.
——— *Urii*, Flem.	Common at one position in shale over Hosie limestone; rare in shale under main limestone.
Spiriferina cristata, var. *octoplicata*, Sow.	Shale under main limestone.
Streptorhynchus crenistria, Phil.	Common. Shale under main limestone.
——— var. *radialis*, Phil.	Rare. Do. do.
Strophomena rhomboidalis var. *distorta*, J. de C. Sow.	Rare. Shale over Hosie limestone.
Terebratula hastata, Sow.	Rare. Shale under main limestone; shale with nodules.

LAMELLIBRANCHIATA.

Ambonychia auriculata, M'Coy.	Rare. Shale under main limestone.
Posidonomya corrugata, Etheridge. (Geol. Memoirs, 23, Lanarkshire.)	Rare. Shale over Hosie limestone.
Aviculopecten arenosus, Phil.	Rare. Shale under main limestone.
——— *ornatus*, Etheridge.	Do. Do. do.
——— *cœlatus*, M'Coy.	Do. Do. do.
——— *interstitialis*, Phil.	Do. Do. do.
——— *Sowerbii*, M'Coy.	Common. Do. do.
——— *semicircularis*, M'Coy.	Rare. Do. do.
——— *Sp.*	Very rare. Shale over Hosie limestone.
Pinna flabelliformis, Mart.	Very rare. Shale under main limestone.
Pteronites, Sp.	Rare. Shale over Hosie limestone.
Arca, Sp.	Very rare. Shale over Hosie limestone.
Edmondia rudis, M'Coy.	Rare. Shale under main limestone.
Leda attenuata, Flem.	Common and very fine. Shale over Hosie limestone.
—— *intermedia*, Etheridge.	Rare. Shale over Hosie limestone.
—— *longirostris*, M'Coy.	Moderately common and very fine. Shale over Hosie limestone.
—— *2 or 3 Sp.*	Rare. Shale over Hosie limestone.
Leptodomus costellatus, M'Coy.	Rare. Do. do.
Myalina Verneuilli, M'Coy.	Common. Shale under main limestone.
Myacites sulcatus, Flem.	Rare. Shale with nodules.
Nucula gibbosa, Flem.	Common and fine. Shale over Hosie limestone.
——— *lineata*, Phil.	Rare. Shale over Hosie limestone.

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Nucula luciniformis, Phil.	Very common. Shale over Hosie limestone.
Sanguinolites iridinoides.	Very rare. Limestone.
——— *Sp.*	Very rare. Shale over Hosie limestone.

GASTEROPODA.

Dentalium inornatum, M'Coy.	Common. Shale over Hosie limestone.
——— *priscum*, Goldf.	Rare. Do. do.
Euomphalus catillus, Sow.	Common and fine. Shale over Hosie limestone.
——— *tuberculatus*, Flem.	Very rare. Shale over Hosie limestone.
Loxonema curvilinea, Phil.	Common. Do. do.
——— *rugifera*, Phil.	Rare. Shale under main limestone.
——— *scalaroidea*, Phil.	Rare. Shale over Hosie limestone.
Macrocheilus acutus, Sow.	Rare. Do. do.
——— *fusiformis*, Sow.	Do. Do. do.
——— *imbricatus*, Sow.	Do. Do. do.
Platyceras neritoides, Phil.	Very rare. Do. do.
Naticopsis elongata, Phil.	Rare. As casts in the limestone.
——— *Sp.*	Very rare. Shale over Hosie limestone.
Pleurotomaria conica var. *decussata*, M'Coy.	Very common. Do. do.
Pleurotomaria Yvanii, Lev.	Very rare. Do. do.
Bellerophon cornu-arietes, Sow.	Common. As casts in the limestone.
——— *Dumontii*, D'Orb.	Moderately common. As casts in the limestone.
——— *decussatus*, Flem.	Do. Shale over Hosie limestone.
——— var. *striatus*, Flem.	Common. Do. do.
——— *Oldhamii*, Portl.	Rare. Do. do.
——— *Urii*, Flem.	Moderately common. Shale over Hosie limestone.

CEPHALOPODA.

Actinoceras giganteum, Sow.	Rare. Shale over Hosie limestone, and as casts in the main limestone.
Cyrtoceras rugosum, Flem.	Rare. Shale over Hosie limestone.
——— *unguis*, Phil.	Common. Do. do.
Goniatites diadema, Golds.	Rare. Shale over Hosie limestone.
——— *Gilbertsoni*, Phil.	Do. Do. do.
——— *excavatus*, Phil.	Rare. Shale over Hosie limestone, and in shale under main limestone.
——— *micronotus*, Phil.	Rare. Shale over Hosie limestone.
——— *mutabilis*, Phil.	Do. Do. do.
Nautilus biangulatus, Sow.	Do. Do. do.
——— *globatus*, Sow.	Do. Do. do.
——— *subsulcatus*, Phil.	Common. Do. do.

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Orthoceras attenuatum, Flem.	Common.	Shale over Hosie limestone.	
——— *cinctum*, Sow.	Rare.	Do.	do.
——— *ovale*, Phil.	Common.	Do.	do.
——— *undatum*, Flem.	Do.	Do.	do.
——— *pyramidale*, Flem.	Rare.	Do.	do.

PISCES.

Cochliodus contortus, Ag.	Very rare. Shale over Hosie limestone.
Helodus planus, Ag.	Rare. Shale under main limestone.
Megalichthys Hibberti, Ag.	Rare. Shale over Hosie limestone.
———	Common. In fish bed and Entomostracan shale.
Palæoniscus, Sp.	Common. Fish bed and Entomostracan shale.
Petalodus rectus, Ag.	Rare. Shale under main post.
Rhizodopsis granulatus, Ag.	Rare. Shale over Hosie limestone.
Rhizodus Hibberti, Ag.	Rare. Good teeth and jaws are occasionaly got in the fish bed.

Besides those enumerated above, about six or seven species of plants too much crushed for identification, and many of them pyritised, have been found in the shale over the Hosie limestone, and in the volcanic ash beds. A number of plates of heads of crinoids, in the shales over the Hosie limestone and under the main limestone, and one undescribed palatal tooth has been found in the shale over the Hosie limestone.

The following species, not mentioned above, are recorded from this locality in the Catalogue of the Fossils of the West of Scotland, by Messrs. Young and Armstrong :—

Alveolites septosa, Flem.	Braehead.
Productus pustulosus, Phil.	Do. Lower limestone.
Platysomus declivis, Ag.	Scales in the Entomostracan shale, Braehead.
Pteroplox brevicornis, J. Young, M.D., and J. Thomson, F.G.S.	Teeth in the Entomostracan shale, Braehead.

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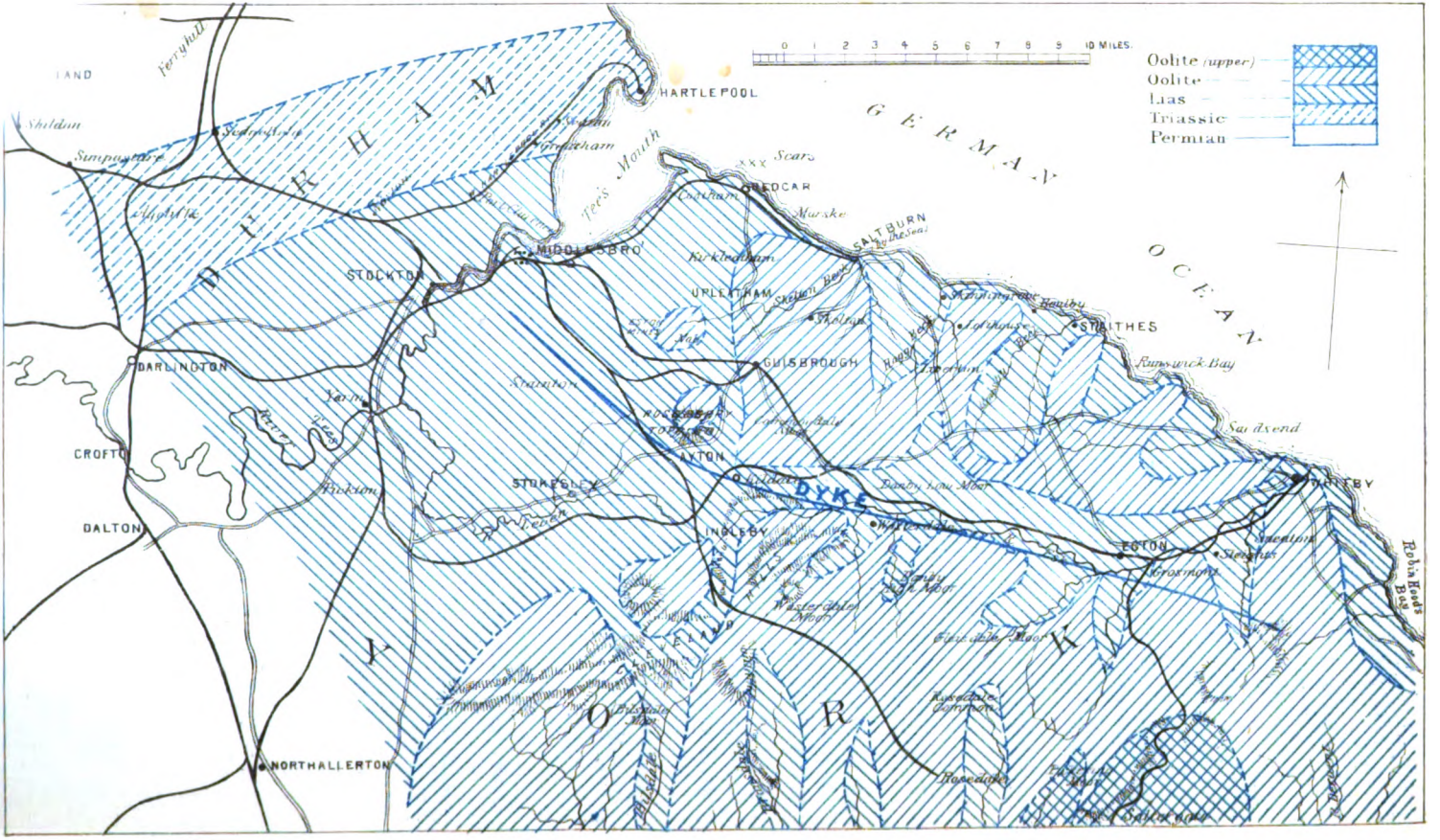

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XXVI.—*On the* GEOLOGY *of the* NORTH-EASTERN DISTRICT *of* YORKSHIRE. By THOMAS M. BARR, C.E.

(Read 13th March, 1873.)

DURING my visit to this locality, the time at my disposal did not allow me to make anything like a systematic or exhaustive study of its geology. But seeing that its geological features differ so widely from those of our own district, while its iron products give it a peculiar interest, a few notes upon it may not be unacceptable to the members of this Society.

The district which I propose to include in this description is that lying between the Tees and Eskdale. The map of the Geological Survey not being yet published, I have prepared one on which the leading geological features of the district are shown.

Perhaps the first thing which strikes a visitor from the Scotch iron districts is the absence, in Cleveland, of igneous rocks, with their consequent upheavals and disturbance of strata. On the north of the Eston Hills, and along the track of the North-Eastern Railway from Darlington to York, the country is generally very flat; but to the east of this line, between Eston and Whitby, it is in many parts exceedingly picturesque. The surface is undulating, but it seldom exceeds a height of from 600 to 800 feet above the sea. "Roseberry Topping," about 3 miles south-west from Guisborough, which forms the most prominent point in the district, is 1022 feet, and "Eston Nab" is 784 feet above the sea. The coast from Middlesborough to Redcar is very flat for a breadth of one to two miles inland. South of Redcar it begins to rise towards Marske and Saltburn-by-the-Sea, where it reaches a height of from 150 to 200 feet, and thence to Whitby it presents bold escarpments, except at those places where a stream has worn down a channel and formed a bay at its mouth. The highest cliff is near Boulby, and is 680 feet in height.

These cliffs consist of numerous beds of limestone, sandstone, and shale, varying in thickness from a few inches to two or three feet, and, from their composition, being very ill adapted to resist the encroachments of the sea and the action of the weather, they are being eaten away much more rapidly than the cliffs on our Scottish coasts. There is a constant falling of loose materials, and

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it is therefore advisable to give them a wide berth when walking along the shore. At the base, in the more exposed parts, the shore consists of rough irregular shingle, the *debris* from the cliffs, which, being subjected to the action of the waves, is ground down to sand and carried into the bays, where it forms the beautiful sandy beaches seen at Scarborough, the north shore at Whitby, and the fine promenade extending from Saltburn to Redcar, about five miles in length, and nearly half a mile in breadth at low water.

Geologically speaking, the whole of the strata are comparatively new, none of them going further back than the Mesozoic period. At the river Tees on the North, which separates the counties of York and Durham, the Trias beds are found underlying the Lower Lias shales of the surface. A bore was put down at Coatham, near Redcar, in 1867, and at a depth of 56 fathoms the new red marl was found.

The classification of the Triassic system is—

KEUPER, { Rhoetic Beds. / New Red Marl. / Lower Keuper Sandstones.

MUSCHELKALK—Not represented in this country.

BUNTER, { Upper Mottled Sandstone. / Pebble Beds and Coarse Red Sandstone. / Lower Mottled Sandstone.

The Middlesborough beds are all considered to belong to the New Red Marl of the Keuper, leaving the other beds still unproved as yet. The system is more completely developed in Cheshire, where it has been carefully examined by Mr. Ormerod, and tabulated as under :—

KEUPER,	New Red Marl,	700 feet thick.
	Lower Keuper,	400 ,,
BUNTER,—Sandstones and Conglomerate,		600 ,,
Total, ...		1700 feet.

In Yorkshire it is not so easy to get at the beds, as they underlie the Lias shales, and are not exposed in cliff sections as in the west. Mr. John Jones, F.G.S., has devoted much attention to them, and has contributed many valuable papers on the geology of the district. From observing the outcrop of the Magnesian limestone in Durham (which is a curved line by Pierce Bridge, Simpasture, Sedgefield, Southwingate Colliery, to the sea between Hartlepool

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and Sunderland), and the dip of the beds in Cleveland, he estimates there must be a thickness of 2640 feet of Triassic beds there. So far as yet proved, they are referred to the New Red Marl, and have been examined to a depth of 1306 feet. If the other beds of the Cheshire Section are represented at Middlesborough, and are the same thickness as in Cheshire, it would give a total thickness of 2306 feet, agreeing very nearly with Mr. Jones' calculation.

A very important circumstance connected with the Triassic beds was the discovering, about nine years ago, of a deposit of rock salt under the works of Messrs. Bolckow & Vaughan, Middlesborough, when sinking a bore for water. This deposit was supposed to be upwards of 100 feet thick, and was proved over a considerable area. An idea was first entertained of pumping it up in the form of brine, but this was found to be impracticable, and the sinking of two shafts was commenced about the end of 1869. In February, 1870, these were down 75 feet, and in March, 1871, 309 feet. The New Limited Liability Company set aside £40,000 for this work, but operations were suspended about six or eight months ago, the company probably having found that their capital can at present be better employed in the iron manufacture. The upper beds of the Keuper are also worked for gypsum, near Lackenby and Eston Station.

Above these Triassic beds we have the alternating shales and limestones of the Lower Lias. These are found in the low-lying ground before referred to, between the Tees and the Eston Hills, running out seawards at Redcar.

It may here be remarked that the strata throughout the district present very little appearance of disturbance or contortion. They are generally found in a position approaching very nearly to the horizontal, and the fineness and regularity of the lamination would indicate that they have been deposited in tranquil seas. I have a small specimen, picked up on the shore, which is a beautiful model of a cliff in miniature. There are fifty-six distinct layers in an inch of its thickness, all perfectly regular and parallel, and the action of the water has worn away the softer beds, leaving the harder ones projecting exactly as is seen on a larger scale in the cliffs.

There is a basaltic dyke extending about sixty miles from beyond Cockfield Fell, in Durham, in an east-south-east direction, to the neighbourhood of Sneaton, where it terminates rather

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obscurely. There is also a dislocation in the line of the harbour at Whitby, the strata on the western side being about 150 feet below the corresponding strata on the eastern side.

The Middle Lias forms the lower portions of the hills, and includes the "Main Seam" of the Cleveland ironstone, the most important deposit of the whole system. It also forms the bottoms of many of the valleys scooped out by the streams. The Cleveland ironstone crops out on the north slope of the Eston Hills, a short distance south of the Tees, and extends southward to near Thirsk, occupying great part of the district lying between the sea and the main line of the North-Eastern Railway, an area of some hundreds of square miles. The "Main Seam" was discovered by the late Mr. Vaughan in the Eston Hills in 1850, and this may be said to have started the Cleveland iron trade, for although iron was known to exist in the district, and several beds of nodular ironstone had been worked before that time, it was only in an irregular manner, and on a small scale. In 1835 Professor Phillips wrote of the ironstone that "at present it is of no value but as ballast," and now the district produces about one-third of the total pig iron made in this country.

It may be interesting here to give a few figures to show the magnitude and rapid growth of this branch of industry, taken from the returns of the Cleveland Iron Masters' Asssociation for 1872:

Make of Pig Iron in	1868, - - -	1,233,418 tons.
,, ,,	1869, - - -	1,459,508 ,,
,, ,,	1870, - - -	1,695,377 ,,
,, ,,	1871, - - -	1,884,239 ,,
,, ,,	1872, - - -	1,968,972 ,,

At the close of the year there were in the district 137 blast furnaces, 130 of which were in blast, and 16 new ones have been erected during the past year. The average product of a furnace is 400 tons per week.

The raw material used per annum is in round numbers—

Ironstone, - - - - - - - -	5,000,000 tons.
Coals from Durham, - - - -	5,000,000 ,,
Limestone, - - - - - - - -	1,500,000 ,,

The number of men employed to make "pigs" is—

Mining, - - - - - - - - -	10,000
Coal Mining, - - - - - - - - -	20,000
Limestone Quarries, - - - - - -	2,000
At Pig Iron Works, - - - - - -	6,000

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The following table, from mineral statistics by Mr. Hunt, F.R.S., in the Memoirs of the Geological Survey of Great Britain, shows in detail the quantity of Iron Ore raised in North Yorkshire in the year 1871:—

District or Mine.	Character of Ore.	Quantity.	Value.
		Tons. Cwt.	£ s. d.
Cleveland Ironstone Mines,	Argillaceous Carbonate,	532,821 11	133,205 0 0
Cargo Fleet,	,,	11,887 0	2,972 0 0
Upleatham,	,,	607,234 15	151,808 12 0
Do. (Hobhill),	,,	427,295 12	106,824 8 0
Lofthouse,	,,	387,376 18	96,844 4 0
Liverton,	,,	290,000 0	72,500 0 0
Normanby,	,,	256,023 0	64,005 0 0
Cliff,	,,	266,084 7	66,521 0 0
Skelton,	,,	114,076 4	28,519 1 0
Port Mulgrave,	,,	135,000 0	33,750 0 0
Belmont,	,,	213,525 10	53,381 5 0
Spa, or Margrave Park,	,,	128,486 0	32,121 5 0
Spa Wood,	,,	59,811 1	14,952 15 0
Belmont, South,	,,	35,871 16	8,967 19 0
Glaisdale (*Yarm.*),	,,	30,000 0	7,500 0 0
Grosmont,	,,	99,509 8	24,877 7 0
Eskdaleside,	,,	29,001 8	6,750 2 0
Birtley (*Eskdaleside*),	,,	5,518 0	1,379 10 0
Crags Hall,	,,	223,984 0	55,996 0 0
Brotton,	,,	414,000 0	103,500 0 0
Rosedale,	Magnetic,	314,394 16	78,598 14 0
Total in North Riding,		4,581,901 0	1,144,974 2 0
Total in West Riding,		407,997 0	101,998 10 0
		4,989,898 0	1,246,972 12 0
Produce of Scotland, Carboniferous,		3,300,000 0	825,000 0 0
Total Produce of the United Kingdom,		16,334,888 14	7,670,572 0 0
Foreign Ores Imported,		524,034 0	
Total,		16,858,922 14	

In the same year the pig iron produced was—

England,	4,379,370 tons.
Wales,	1,087,809 ,,
Scotland,	1,160,000 ,,
Total,	6,627,179 tons.

The "Main Seam," as before stated, crops out on the north face of the Eston Hills, where it is from 14 to 16 feet in thickness, and it continues all round by Upleatham and Saltburn to Skinningrove. It shows along the coast to Whitby, but south of Skinningrove the deposit is thinner, and is also split up by the

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intercalation of beds of shale: the stone is also poorer in iron. From the coast it extends inland to Belmont and Guisborough, getting thinner as it runs westward from the latter place. The principal mines are in the Eston Hills, and in the area extending about six miles to the south-east of Guisborough and Upleatham, with a breadth of about four miles. The best stone is found within this area of about 27 or 30 square miles.

The stone is a carbonate of the protoxide of iron. The following is a detailed analysis of the Eston stone, from the Memoirs of the Geological Survey, and, through the kindness of Dr. Wallace, I am enabled to give, for comparison, analyses of two samples of "Blackband:"—

	Cleveland.	Blackband.	
		Fine.	Medium.
Protoxide of Iron,	39·92	48·73	43·06
Peroxide of Iron,	3·60	trace	trace
Protoxide of Manganese,	0·95	.....	.....
Alumina,	7·86	0·20	5·65
Lime,	7·44	4·78	3·62
Magnesia,	3·82	3·47	2·76
Carbonic Acid,	22·85	37·34	32·20
Phosphoric Acid,	1·86	0·40	0·60
Sulphuric Acid,	trace	.....	.....
Sulphur,	0·11	0·30	0·21
Iron in Combination with Sulphur,		0·26	0·18
Silica,	7·12	0·60	6·84
Bituminous or Organic Matter,	trace	3·44	3·79
Potash,	0·27	.....	.....
Water in Combination,	2·97	0·48	0·96
Insoluble Residue, chiefly Silica,	1·64	.....	.....
	100·41	100·00	99·87
Metallic Iron in Sample,	33·62	38·16	33·68
Specific Gravity,		3·226	3·125

The Upleatham stone gives 31·97, and the Normanby stone 31·42 of Metallic Iron.

At the present time it is not considered profitable to work a stone which has less than 24 per cent of Metallic Iron, and each unit of iron above that is roughly estimated as adding 6*d.* per ton to the value of the stone. The average cost of the stone in 1871 was 3*s.* 6*d.* to 4*s.* per ton, and the Royalty usually paid was about 5*d.* per ton. I have not been able to get later rates. The pigs from the Cleveland stone have about $1\frac{3}{4}$ per cent. of

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phosphoric acid, and the presence of the phosphorus makes it what is technically called "cold short," unless it is mixed with other makes. The Cumberland Hematite is generally used for this purpose, experience having shown that this mixture gives a very good quality of iron. The Cleveland district iron had long a bad character in the market, and it was a common practice, quite recently, for engineers in their specifications to forbid its use. The energy, however, shown by the makers in improving the manufacture, and adopting proper mixtures, is fast removing all cause for complaint. I had occasion to test a good deal of it, and the first results were so very good that I doubted the accuracy of the machine, and samples were sent to Mr. Kirkcaldy, of Southwark, for verification. The following table shows the average results of Mr. Kirkcaldy's tests:—

Cleveland Wrought Iron.				
Description.	Ultimate Tensile Strain in Tons per Square inch.		Extension at Time of Fracture, per cent.	Appearance of Fracture.
	Original Area.	Fractured Area.		
Girder Plates,	22·76	27·58	12·8	Fibrous.
Angle Iron, -	23·80	29·61	18·1	do.
Rivets, - -	25·55	43·59	.....	do.

From the position of the seam, the mines are mostly worked on what Scotch miners call the "ingaun e'e" plan, there being very few pits sunk, and none more than 100 fathoms in depth. In the mines they have from four to five yard cuttings, leaving posts of the same size, and removing the posts as they work back. The general dip of the strata is about 1 in 16 towards the south-east. From the thickness of the seam, and the regularity of the strata, the working has very little of the risk and anxiety of the ironstone mining in the carboniferous system, where the miners have to contend with numerous faults and troubles, often shifting the beds many fathoms. The Cleveland miner is also free from the danger of explosive gases. The only place I heard of where these occur is at Liverton, to the east of Saltburn, where some of the beds are charged with bituminous matter. The principal drawback in the Cleveland iron manufacture is the want of coal, which has to be brought from the coal fields in Durham and west of Darlington. Most geologists now consider these to be self-contained coal basins, but others think the carboniferous beds underlie the Cleveland

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strata, and more than one attempt has been made to prove this. A bore was sunk some years ago near Yarm, but after going down 120 fathoms it was stopped at the magnesian limestone. It is difficult, however, to see what practical good would be derived from them, if they do exist in that position—as, supposing the strata uniform and persistent, the coal must lie much deeper than can be reached by our present appliances for mining. I went down the Adelaide Pit, near Shildon, and there it is 176 fathoms, or 1056 feet, to the coal. This pit is situated about three miles to the north of the outcrop of the Permian; and taking the dip of the beds at 1 in 16, or 330 feet per mile, this gives 2046 feet from the coal to the Triassic; adding the thickness of the Triassic as before found to be 2306 feet, and the depth of the bore at Coatham 336 feet, gives a total depth of 4688 feet from the surface near Middlesborough to the coal beds. The deepest coal mine in England is said to be at Roxbridge, near Wigan, which is 2726 feet, or little more than half the depth which would require to be sunk in the north of the Cleveland district.

So far as yet examined the ironstone beds are thicker and richer on the north of the district, and it is here that mining operations are chiefly carried on; but as these get worked out, more attention will, no doubt, be given to the beds further south.

The limestone used at the furnaces is brought from Stanhope, Merrybent, Forcett, Pickering, and Ferryhill.

The upper Lias comes above the "main seam," and in it there are several shales which are worked for alum; also a good deal of jet. Near the top of the series a bed of ironstone, called the "top seam," has been discovered; but it is very unequal in thickness and quality, sometimes rising as high as 40 per cent. of metallic iron. It is being wrought in Glaisdale and Rosedale.

The hills are capped with masses of oolite sandstone, those to the north having the lower beds of the oolite only, the upper beds appearing as we travel southwards. The Kimmeridge clay is found in the Vale of Pickering, and extends a little to the south of the River Derwent. The lower members of the chalk crop out in a line extending from Malton to Filey Bay. The district south of this line is occupied by the chalk, which in turn is overlaid by Tertiary Beds. These latter extend southward of a line from Driffield to Bridlington, and east of Beverley, the outcrop agreeing very nearly with the line of railway from Hull to Bridlington.

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The general features of the Liassic system may be said to be the frequent alternations of beds of shale, limestone, sandstone, ironstone, &c. The shales yield alum, pyrites, &c. The limestone has long been famous in England, where the "Blue Lias Limestone" is of frequent occurrence in specifications. It contains 80 to 90 per cent. of carbonate of lime. The sandstones are many of them first-class building stones.

There are several accumulations of "Drift" in the Tees Valley, filling up the hollows in the older rocks, consisting of stiff purplish clay, containing boulders of the rocks found to the westward, and also several deposits of gravel, like moraines.

Any description of this district would be incomplete without some reference to the fossil remains, which are such a marked feature of the Oolitic system. I found very few of these north of Saltburn-by-the-Sea, but I have reason to think that this was in great measure due to the want of information as to the proper localities, as I have since learned that there are some very rich deposits in the lower Lias in that part of the district. To any one with limited time at his disposal I would recommend Whitby as the best locality for his head-quarters. I first tried the north-west shore and cliffs, but got very few good specimens. On crossing the harbour to the east shore I was more successful, the specimens there appearing to be more abundant, and in better preservation. A stranger must, however, be very cautious, and watch the sea, for, as the beach is only accessible at certain states of the tide, unless a good look-out is kept the retreat may be effectually cut off. It is well, also, to keep away from the cliffs, as the constant falling of loose materials makes it rather dangerous to work near them, and plenty of good specimens are to be got from the fallen blocks on the shore. If time permits, the visitor should extend his excursion southward, along the shore to Robin Hood's Bay, a distance of 6½ miles, or by taking the road 1½ mile of this distance may be saved. The most common shells are:—*Ammonites*, of which there are said to be 120 species, and these serve for the correlation of the strata in different parts of the country, as it is found that certain species are peculiar to particular beds. The Cephalopoda do not appear to have been so numerous, nor do they present such a variety, during any other period as during the deposit of the Oolitic system. *Belemnites* are very common, and are sometimes of a very large size. The *Gryphæa* is peculiar to

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this system. I also got several genera, as *Terebratula, Rhynconella, Pecten,* &c., which are represented in our Carboniferous strata, and a very perfect specimen of a ganoid fish from Robin Hood's Bay. Reptilian remains are found in considerable abundance, some of the specimens being very complete and of great size. I had, however, to be content with part of the snout of an *Ichthyosaurus*, and three vertebræ of a *Plesiosaurus.*

One of the leading industries of Whitby is the manufacture and sale of jet ornaments. The jet is found in thin seams in the cliffs, and the collection of it is looked upon as a rather hazardous occupation. A very popular ornament, apparently, is a brooch, consisting of a polished section of ammonite set in jet. There is also a considerable trade in fossils, and many of the inhabitants seem more inclined to sell specimens than to give information as to where they are to be found.

This is neither the time nor the place to enter upon the antiquarian remains, in which the district is exceedingly rich; but to any one, be he geologist, botanist, antiquarian, or simply an admirer of the wild or romantic in nature, I am sure a visit to the north-east of Yorkshire will be one of the most enjoyable of trips.

XXVII.—*Notes on the* Glaciation *of the* West of Scotland, *with reference to some recently observed instances of* Cross-Striation. *By* Dugald Bell, *Corresponding Secretary.*

(Read 14th Nov., 1872.—Abridged.)

In the neighbourhood of the Firth of Clyde, the relics of the glacial period—which are well-marked and abundant—indicate that the ice spread out in various directions from the mountainous districts of Argyle and Dumbartonshires, westward over the hills of Knapdale and Cantyre, eastward across the midland valley of Scotland, and southward over what is now the Firth of Clyde. These diverging striæ and trains of boulders must have been produced by a great sheet or *nappe* of land-ice, extending from the higher grounds, entirely filling up the present estuary of the Clyde, and overflowing all the minor elevations on either hand. The branching "lochs," which form such a striking feature of the Firth and of the West Coast generally, are simply old glacier channels, down which, in various directions, this great

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outflow of ice found its way from the frozen and snow-clad interior of the country. The lower part of the Firth seems to have been entirely filled up by the ice issuing from Loch Fyne, Loch Ridden, and Loch Striven, on the one hand, and from the high grounds of Ayrshire on the other—Arran also contributing its quota; while that which proceeded from the Holy Loch, from Loch Long and the Gareloch, and from Loch Lomond, was, in consequence, forced to take an easterly direction opposed to the present inclination of the valley.

That a sheet of land-ice sufficient to striate the Pentland Hills to a height of 1500 or 1600 feet stretched at one time across the midland valley to the German Ocean, is quite in harmony with the evidences of the immense mass of the ice which then occupied the whole breadth of what is now the estuary of the Clyde.

At no point, perhaps, can these evidences be better studied than in the neighbourhood of Greenock and Gourock, directly opposite the openings of the lochs last referred to. As the Clyde below Greenock turns into the line of junction between the Old Red Sandstone and the Clay Slate, the rocks on that eastern side of the river are entirely Old Red Sandstone, lower Carboniferous Sandstones, and Trap. This makes all the more remarkable the immense number of boulders of schistose, gneissose, and granitic rocks—some of considerable size—which are strewn along the shore and to some height on the hillsides, and which have evidently been derived from the mountainous district extending to the north and west, on the further side of the Firth.

Wherever a bank of boulder-clay, too, is exposed, either on the shore or in the cutting of any little stream, the bluish slaty character of the till resting on the red-coloured sandstone is very noticeable. This has been remarked up to a height of 500 or 600 feet. (See Note A.)

The striæ on the hill-tops point to the same quarter. On the hills behind Gourock and Greenock (500-800 feet) they point N.W., or in the direction of the Holy Loch and Loch Long. Lower down, however, cross-striæ appear; in some instances three different markings are visible, while near tide-mark, at several places—as at the Cloch, at Inverkip, and on the Cumbraes—they correspond to the present line of the river. These lower striæ, it is evident, must be of later date than the higher ones, and mark a period when, the ice shrinking in bulk, and the southern portion

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of the Firth becoming more open, a change took place in the direction of some parts of the ice-stream, conforming more to the present course of the river.

As was pointed out, nearly thirty years ago, by Mr. Charles M'Laren,* the Gareloch, during the glacial period, was occupied by ice which crossed into it, over the ridge at its upper extremity, from Loch Long. Probably the inflow of the Lochgoil glacier, nearly opposite, may have caused this deflection from the main line of the loch. But the general eastward motion of the ice at this part of the Firth (when at its maximum) is proved by many particulars. The Loch Eck glacier, issuing from the Holy Loch, seems to have been powerful enough to turn very much to the east the lower portion of the Loch Long glacier; and the boulders in the neighbourhood of Greenock and Gourock—evidently a prolongation of the train of boulders seen at Strone Point—may be held to mark the "medial moraine" of the united glacier which they formed. The Roseneath or Kilcreggan Hill—the low ridge of clay-slate extending between the Gareloch and Loch Long—was also deeply buried under the ice, which moved across it in a slanting direction towards the east. Similarly, the hill behind Row and Helensburgh is glaciated from the west, and clearly indicates that a part of the ice-stream passed eastward at this point from the Clyde into the Loch Lomond valley. And yet, as shown by the markings on Ben Lomond, the upper portion of what is now Loch Lomond was occupied by ice exceeding 2000 feet in thickness. Further, owing to the pressure of the ice from the west, the Loch Lomond glacier seems at one time to have mainly proceeded by the eastern end of the Kilpatrick range, through the Strathblane valley, or along the Fintry hills in the direction of Stirling.†

Between Greenock and Bowling the ice occupied the present channel to a great depth, passing on the one hand across the hills behind Port-Glasgow into the Gryfe valley by Kilmalcolm, and extending towards the Vale of Leven on the other. Pressing on across the Kilbarchan and Kilpatrick hills on either hand, and occupying entirely the space between them, it advanced over the Forth and Clyde valley, strewing it with innumerable fragments of West Highland rocks, and maintaining, as shown by the striæ, a general easterly or south-easterly direction, varying to some extent, in some places, from local causes.

* *Scotsman*, October, 1845. *Edin. Phil. Journal*, January, 1846. † Note E.

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That the present outlet of the Clyde, by Bowling, was thus for an immense period blocked up by ice; that during the earlier, and again during the latter stages of the glacial epoch, this would be the case, while the wider part of the valley, immediately beyond, was comparatively free of ice; and that then the waters of the Clyde, accumulating in that part as a great fresh-water lake, must have found egress in another direction—these circumstances, as suggested by the writer in a paper read to this Society a few years ago,* are no mere probabilities, but as certain as anything relating to the period in question can well be. And it is essential that this condition of things be kept in mind in investigating the superficial deposits of the part of the Clyde valley now referred to. (See Note B.)

Mr. BELL then stated that, while the general glaciation of the Forth and Clyde valley is from W. to E. (or N.W. to S.E.), yet in some places there had lately been observed instances of cross-striation, which were of considerable interest to students of this department of geology; and to one of these—namely, that at Possil, he wished more particularly to call the attention of the Society. He described the section at Possil as presenting two remarkably distinct sets of striæ—one from the usual direction (in this neighbourhood) of N.W., or N.W. by W., and the other from nearly due E.† The section had been carefully examined by several members of the society, who had no doubt that the N.W. striæ were the older of the two sets, and the N.E. the newer. The latter were not only fresher and more continuous, but had nearly obliterated the former, except in some hollows and sheltered places where these had had a better chance of being preserved. The only point of difference between some of the observers was as to whether the newer set had been formed by *land*-ice or *drift*-ice. The drift-ice theory seemed at first to be the simpler or more likely hypothesis—viz., that when the land was submerged after the first or general glaciation (in this part from the N.W.), bergs continued to drift across the submerged tract, grounding here and there, and producing the newer grooves and markings under consideration. On the other hand, it was difficult to imagine that drift-ice could produce such regular markings as those in question. If so produced, it was thought they would bear

* April, 1870. (See present Vol., p. 66.)

† See present Vol., p. 224. (See also Note C.)

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from various directions, and perhaps as much from the west as from the east. It was difficult also to suppose that drift-ice could so insinuate itself into the hollows and inequalities of the rock, grooving and polishing even the vertical faces of the little outstanding ridges, as the agent which had produced these N.E. striæ had done. Besides, there was the accumulation of the overlying till or boulder clay to be accounted for, which here attains a thickness of from 20 to 25 feet, is of the usual stiff consistence, and is thickly charged with fragments of rocks from the N.W., mingled with local boulders—some of which may have come from the Campsie district to the N.E.—and most of which are distinctly striated. The difficulties as to land-ice having produced these later markings are of another kind. If land-ice, it must have been sorely diminished in bulk from the older ice-sheet, as it has produced a comparatively slight effect, has not entirely obliterated the older striæ, and has only partially altered the face of the rock. But a stream of ice coming to this point from any but a short distance to the N.E., must have passed across the Campsie Hills where they attain an elevation of 1200 to 1400 feet. There was no evidence of such a mass of ice having come in that direction at any time, and least of all subsequently to the N.W. glaciation. It would have left its marks unequivocally on the Campsie Hills, and have produced a much greater effect on the low grounds on which it descended. If land-ice, therefore, it must have been comparatively slight in bulk, and have reached this spot in some other way than by coming across these hills. He thought a solution of the difficulty might be arrived at by considering that, as the ice shrank in bulk, instead of one continuous sheet, it would in many parts assume the form of so many more or less separate streams. Obstacles in its path, such as the Kilpatrick range of hills to the N.W., over which it might pass undeflected for a long period, would in course of time suffice to part it. In such circumstances there would be two main inflows of the ice towards this portion of the central valley—one past the south-west or Kilpatrick end of the range, and the other past the north-east, or Strathblane end. This was quite confirmed by an examination of the points referred to. Thereafter, at whatever point these two streams met, as they spread out in the valley behind, it was evident the direction of the striæ would be determined by the equipose, so to speak, between them. If the one shrank in bulk

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more than the other, a change in the direction of the striæ they were producing would certainly ensue. Now, from its greater proximity to the sea, and owing partly to the Firth gradually becoming more free of ice, nothing was more likely than that the stream entering from the south-west should shrink more rapidly than that from the north-east, and hence the later markings would bear evidence of an inflow of ice from the last-mentioned direction, passing for some distance along the Strathblane valley, and gradually spreading out over the neighbouring ground. He made this suggestion with the view of obviating some of the difficulties which seemed to beset any explanation of the facts, and should be glad if any one present had another and a better to offer.

NOTES.

A.

THE following are a few of the more conspicuous boulders which may be noted to the south of Kempoch Point:—

(a) Opposite George Place, a large oblong mass of dark hornblendic schist, "end on" to the shore, at about half-tide mark, striated lengthways. Estimated about ten tons.

b) Opposite Ashton, near high-water mark, a large rounded boulder of mica slate, plentifully veined with quartz. Also about ten tons.

(c) A quarter of a mile below the toll, an oblong boulder of gneissose schist, by the side of the road, twelve feet above high water. About four tons.

(d) Near the Cloch Inn, by the side of the road, a boulder of granite, with flesh-coloured felspar (now broken up) weighing three to four tons. Smaller boulders of the same granite occur along the shore.

(e and f) Near the same place, but higher up, two small boulders of mica schist, one twenty-five feet, the other forty feet above the sea level.

(g) Below Cloch Light House, two blocks of fine-grained gneissose schist, resting on sandstone, near high-water mark. About three tons each.

(h) At Lunderston Bay, a large oblong boulder of gneissose schist, with quartz veins, resting on sandstone and mottled shale. About twelve tons. A smaller one near it, of two tons.

Perhaps the above list should have begun with an obelisk of gneissose schist just on the slope of Kempoch Point, about 50 feet above high water, which from its resemblance, at a little distance, to a human being, has been called the "auld wife o' Kempoch," and was supposed in olden times to have some influence over the winds which often blow so strongly and conflictingly off this Point!

(The Castle hill, immediately behind, is striated diagonally from north to south, two well-marked lines of striæ occurring at 200, and again at 300 feet above the sea. The direction bears across the Inverkip valley towards Loch Thom.)

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These are but a few of the more noticeable boulders, and they are all on or near the sea-shore. But great numbers are also found on the hill-side, chiefly, as far as my observation goes, within the 200 and 300 feet line above the sea, and varying from a few cwts. up to two or three tons in weight. Most of the larger boulders within the zone of cultivation, it is to be remembered, have been broken up and cleared away. But there may be other reasons connected with the gradual recession of the ice why the larger-sized boulders should be chiefly found near the present sea level.

The height at which both the boulders and the slaty till are found, seems to depend very much on the nature of the subjacent rocks, whether they permitted the formation of a gradual slope or not. Where the rock is a ridge or boss of hard trap, the materials of the till seem to have got *scraped off* sooner, and do not occur so high or so plentifully as on the softer stratified rocks.

I may here mention that, on the flanks of the Kilpatrick hills, erratics may be found at considerable heights; one of mica schist I have observed in the neighbourhood of Old Kilpatrick, about 380 feet above high water, and weighing fully two tons.

A few years ago, in cutting drains in a field near Erskine, on the opposite side of the river, a great number and variety of boulders were gathered out—West Highland rocks of the usual types, mingled with a considerable proportion of the adjacent traps.

See also Mr. J. Young's enumeration of the boulders found at Gilmore-hill.—(*Trans. Geol. Soc., Glas.*, Vol. III., p. 304.)

B.

While the present Part is passing through the press, I have had the pleasure of perusing the admirable work on "The Great Ice Age," recently published by Mr. James Geikie, F.G.S., F.R.S.E., of H.M. Geological Survey of Scotland. I am happy to find myself in accord with the able author on the point referred to in the text, viz., the damming up by ice of the present outlet of the Clyde, and the formation of a glacial lake over the tract of ground around Paisley, the waters then escaping by the Black Cart and Lochwinnoch valley. Mr. Geikie works out the proofs of this condition of things with great force and clearness (pp. 185 *et seq.*), and adds that the discharge of this ancient glacial lake may at some periods have been "to the north-east by Kilsyth into the basin of the Forth," seeing that "the difference of height between the watershed at Kilsyth and that at Black Cart is only some fifty feet or so" (p. 191). This I also think highly probable.

The only point on which I am inclined to take a slightly different view from Mr. Geikie is with regard to the Loch Lomond or Leven glacier having been the chief agent in preventing the outflow of the Clyde by the present channel. The evidence, so far as I have been able to gather it, leads me to believe that when the Loch Lomond glacier reached the present bed of the Clyde, it was met by ice of at least equal bulk, proceeding from a more westerly source, by which the channel was already blocked up.

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But this, though of some little interest, perhaps, in itself, is on the whole of no great moment.

I may add in connection with this, however, that Dumbarton Castle rock, at the confluence of the Leven with the Clyde, appears to me to present clear indications of having been acted on by ice from the west. I am aware that the striæ in the narrow chasm or fissure pointing north and south—described by Captain Brickenden in the Quarterly Journal of the Geological Society for 1855—are usually referred to as the work of ice from the north, *i.e.*, from Loch Lomond. But I am not sure that they must be so. These striæ present some puzzling features. They are chiefly seen on the western or overhanging side of the fissure, and appear very sparingly on the eastern side; but when they do occur on that side—towards the top—they undoubtedly sweep out towards the east. It is not easy to account for the greater action which the ice seems to have had under the slope on the western side; but may it not be the result of its being influenced, while wedged into and passing through the fissure referred to, by the general motion of the ice of which it formed a part, from the west? The ice on that side of the fissure would thus, in all likelihood, be dragged or pressed through with increased velocity, and so produce a greater effect on the rock with which it was in contact. Whatever may be thought of this, there seems at least no improbability in the general suggestion now made. Professor Ramsay, in his excellent paper on "The Old Glaciers of Switzerland," notices that at the lake of Grimsel, "a long, narrow, high, rounded barrier of solid rock, over which the glacier formerly poured, crosses the valley, damming up the lake in that direction; and here, so great has been the pressure, that I found proof of the ice having been forced into a narrow transverse fissure, which it polished and striated quite out of the direction of its general flow" (p. 17).

On the other hand, had the Loch Lomond glacier maintained its course unimpeded till it abutted on the Kilbarchan range of hills, opposite Dumbarton, which is the only other supposition, we should expect to find there northerly striæ, and greater accumulations of *debris* than have yet been observed. All the evidences in that neighbourhood indicate, as already stated, a general motion of the ice from the west.

In December, 1871, Mr. T. F. Jamieson, F.G.S., of Ellon, acknowledging receipt of a short sketch of the glaciation of the Clyde valley, which had been sent him, and alluding to some remarks the writer had made on the curve or shedding of the ice, which appears to have taken place on the high grounds between Lanarkshire and Renfrewshire, wrote as follows:—"With regard to the direction of the striæ, to which you refer in your note, it seems to me that we ought to expect a considerable divergence in the neighbourhood to which you allude. During the period when the land-ice was at its maximum, we may suppose that great masses of glacier-ice came down from Loch Lomond, the Gareloch, Loch Long, &c., into what is now the mouth of the Clyde. Another flow of glacier-ice, from an opposite direction, would come down the valley of the Clyde, and would meet the other somewhere—probably about Glasgow. It is clear that if the glacier-ice coming

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down from Loch Lomond, &c., was in great force, it would block up the mouth of the Clyde, and prevent the Clyde glacier getting out by the present course of the river. I should expect, therefore, that the striæ would change their direction accordingly, and that the conflicting pressure of the two glaciers would result in a movement to the south-west."—(*26th Dec.*, 1871.)

It is interesting to notice how exactly this accords with the conclusions which Mr. Geikie, from his intimate knowledge of the district, has arrived at:—"During the climax of the glacial cold, the lower reaches of the Frith of Clyde were choked up with ice descending from the mountain glens of Argleshire; and hence the ice that streamed down the Gareloch and the valley of the Leven was forced to overflow the high grounds behind Greenock, and so to continue on its way *up* the valley of the Clyde towards Glasgow. Hereabouts the pressure of the ice-sheet advancing from the south began to be felt, and a portion of the high-land ice stream became deflected, flowing first south-east, then south, and lastly, south-west; while another portion continued on its easterly course across the whole breadth of the country to the North Sea."—*The Great Ice Age* (Appendix H., p. 565).

C.

A very interesting portion of the Possil section was where a small block of sandstone, about three feet by two, flat-topped, and striated on top and sides from the N.E., lay upon a part of the rock distinctly marked with the older striæ from the N.W.

In the cuttings near Maryhill for the branch railway to Stobcross, an oblong boulder of greenstone, five feet by three, was exposed in the till, about eight feet from the surface, its longer axis lying E. and W., and striated in the same direction. But it exhibited also a later series of markings from the N.E., which well-nigh obliterated the older markings, and which seemed to have been made after the block had taken the position in which it was found embedded in the till.

D.

Looking to the proofs of the immense volume of the ice which issued from the mountainous region to the north of Loch Lomond, Loch Long, and Loch Fyne, one is almost led to think that at least some part of this district must have *stood higher*, relatively, to the Old Red and Carboniferous formations to the south than it does now. The late Mr. C. Maclaren, in his paper, referred to in the text, on the evidences of ice action at the Gareloch, remarked, that "while the mountains beyond Loch Long and Loch Lomond are exceedingly rough in the surface, carbuncled all over with bare protuberances, and have a serrated outline singularly bold in its salient points, the ridges within the peninsula [of the Gareloch] exhibit an appearance exactly the reverse. Their sides are comparatively smooth, and much more covered with peat and turf, while their summits are either straight lines or gently-undulating curves. The contrast in the outward aspect of the two sets of hills (continued Mr. Maclaren) is so striking as to impress an observer with an idea that the rocks must be different, though they are

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perfectly the same. Probably both have undergone abrasion to some extent, but we cannot help inferring that the abrasion has been ten times greater in the one case than in the other."

All who have looked across from Greenock to the hills north of Gareloch, will acknowledge the truthfulness of this description. And the difference in height does not seem to be sufficient to account for this difference in appearance. Even granting some difference in the rocks, what could that be to ice of such thickness as to leave its markings *across* Ben Lomond at a height of more than 2000 feet? But may there not have been a *subsidence*, to some extent, along a tract of these hills, which look so remarkably rugged in proportion to their real size? It is clear there has been at *some* period a great dislocation, or faulting down of the strata, along a great part of the highland border; and this is especially noticeable in the neighbourhood of the Gareloch—the dip of the Old Red Sandstone being there for some distance *reversed*. And if it be thought, on the first view, improbable that any such disturbance or change of level should have taken place so comparatively recently as the glacial epoch, it may be noted, as a fact worthy at least of being borne in mind, that the tract referred to is quite in the line of any earthquake tremors experienced in Scotland at the present day.*

Mr. Maclaren's idea was that when the group of hills extending from Loch Eck to Loch Katherine formed a *mer de glace*, "the ice, jammed into the sinuosities of the valleys, would remain nearly immovable, and would have little abrading action." Hence the roughness of the rocks in that portion; while, from the outskirts of the group, icebergs breaking off "would rub and grind the surface of the lower hills over which they passed." There need be no disrespect to the memory of the accomplished author in saying that the objections to this are many and strong.

If, however, there should appear to be any probability in the above suggestion, it must be wrought out with some care and fulness at another time.†

On the other hand, there are several considerations which must be borne in mind:—

(1.) With regard to the ice proceeding in such mass from a region in great part not higher than many of the hills over which it passed, we

* Here is the last instance recorded, three years ago:—"About eight o'clock, on Saturday night (15th April, 1871), a smart shock of earthquake was felt in various places on the West Coast, and in Dumbartonshire, accompanied by a noise like a discharge of cannon. Numerous correspondents and coast residents at Gareloch, Roseneath, Kilcreggan, and Kilmun state that they distinctly felt the shock." Then follow extracts from the letters of correspondents from Luss, Helensburgh, Roseneath (Rev. R. H. Story), Kilcreggan, Kilmun, Dunoon, Glenlean, near the Holy Loch, and Inverchaolin.—*Glasgow Herald, 17th April*, 1871.

† I am reminded that Professor Nicol, of Aberdeen, wrote a paper fully ten years ago on "The Geological Structure of the Southern Grampians," in which he pointed out the existence of a great line of fault between the Old Red Sandstone and the slates across nearly the whole of Scotland, and stated, that the appearance of eruptive rocks at several points along this line showed that it had been at various periods an axis of disturbance. I have not the paper at hand to refer to, but, if I mistake not, it appeared in the *Quarterly Journal of the Geological Society* for 1863.

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ABSTRACTS OF PAPERS.

[The publication of several papers, in full, being unavoidably delayed, the following abstracts are in the meantime given.—*Ed.*]

I. President's Address.

(12th February, 1874.)

The Annual Meeting of the Society was held in the Natural Philosophy Class-room of the University. After the election of Office-bearers for the ensuing year,

Sir William Thomson (who was accompanied by Dr. Carpenter, late President of the British Association, and by other scientific gentlemen) delivered the annual address as President of the Society. Having thanked the members for his re-election, he proceeded to offer some observations on the "Influences of Geological Changes on the Earth's Rotation." He first briefly considered the rotation of rigid bodies in general, defining a principal axis of rotation as one for which the centrifugal forces balance while the body rotates around it. He then took the case of the earth; and, having pointed out the position of its present axis, showed that if from any cause it were made to revolve round any other, that would be an "instantaneous axis," changing every instant, and travelling through the solid, from west to east, in a period of 296 days, round the principal axis. It would shift continually in the figure, owing to the varying centrifugal force of two opposite portions of the body. This would produce, by centrifugal force, a tide of peculiar distribution over the ocean, having 296 days for period. An inclination of the axis of instantaneous rotation to principal axis of 1″, or 100 feet at the earth's surface, would produce a rise and fall of water in 45° latitude, where the effect is greatest, amounting to ·17 of a foot above and below mean level.

He noticed, in passing, the application of these dynamical principles to the attraction which the sun and moon exercise on the protuberant parts of the earth, tending to bring the plane of

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the earth's equator into coincidence with the ecliptic. This causes an incessant change, to a certain limited extent, in the position of the axis of rotation, thereby occasioning what is known as the "precession of the equinoxes." Having illustrated these remarks by some interesting experiments, Sir William proceeded to consider more particularly the circumstances according to which the axis of the earth might become changed through geological influences, and the consequences of any such change. The possibility of such a change had been adduced to account for the great differences in climate which can be shown to have obtained at different periods in the same portion of the earth's surface. In the British Isles, for example, and in many other countries, there is clear evidence that at a comparatively recent period a very cold climate —much colder than at present—prevailed; while in the same places the remains of plants and animals belonging to several preceding eras indicate a high temperature and a comparatively tropical climate. The question arose, can changes in the earth's axis account for these changes of climate? In the present condition of the earth, any change in the axis of rotation could not be permanent, because the instantaneous axis would travel round the principal axis of the solid in a period of 296 days, as already stated. Maxwell had pointed out that this shifting of the instantaneous axis in the solid would constitute in its period a periodic variation everywhere of "latitude," ranging above and below the mean value, to an extent equal to the angular deviation of the instantaneous axis of rotation from the principal axis; and by comparing observations of the altitude of the Pole-star during three years at Greenwich, had concluded that there may possibly be as much as $\frac{1}{2}''$ of such deviation, but not more.

In very early geologic ages, if we suppose the earth to have been plastic, the yielding of the surface might have made the new axis a principal axis. But certain it is that the earth at present is so rigid that no such change is possible. The precession of the equinoxes shows that the earth at present moves as a rigid body; and during the whole period of geologic history, or while it has been inhabited by plants and animals, it has been practically rigid. Changes of climate, then, have not been produced by changes of the axis of the earth. The learned Professor then inquired what influences great subsidences or great elevations in different parts of the earth might have on the axis of rotation. No doubt the

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removal of a large quantity of solid matter from one part of the globe to another would sensibly alter the principal axis, as well as the axis of rotation, which so nearly coincides with it; but it could be shown that it would produce in the latter only about 1-300th part of the change produced in the former. We know too little of the changes in the interior of the earth accompanying such changes on its surface to be able to state results with certainty. But he estimated that an elevation, for example, of 600 feet on a tract of the earth's surface 1000 miles square and 10 miles in thickness, would only alter the position of the principal axis by *one-third of a second*, or 34 feet. He called attention to the effect of tidal friction and subterranean viscosity in reducing any such deviation, and pointed out that it must be exceedingly slow—using for evidence the observationally proved slowness of the diminution of the earth's rotational velocity, and of the inclination of its equator to the ecliptic. It therefore seemed probable that geological changes had not produced any perceptible change in the principal axis or in the axis of rotation within the period of geological history.

II. *On the* Stratified Rocks *of* Islay. By James Thomson, F.G.S., *Vice-President.*

(Read 14th December, 1871.)

Having briefly noticed the topographical features of the island, the author pointed out, by means of a map and sections, the relative positions of the sedimentary rocks. He described in detail the sedimentary deposits on the south side of the island, and then gave a transverse section of them, from Port-na-Haven on the west to Port-Askaig on the east. Although the rocks in the central valley of the island had not yet yielded identifiable organic remains, he did not despair, if properly investigated, of forms being found that would place them beyond doubt in the Lower Silurian series. In mineral character, they quite coincided with those described by the late Sir Roderick Murchison as occurring in Ross and Sutherland shires. On the east side of the island, at Port-Askaig, these deposits repose upon a series of stratified rocks of much higher antiquity, which correspond to the Cambrian rocks of the North-west Highlands described by the same distinguished

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author. At the base of these latter sedimentary rocks there is a mass of conglomerate made up of fragments and boulders of granite, embedded in an arenaceous talcose schist; and as no granite occurs *in situ* in the island, he was disposed to account for its presence in this conglomerate by the agency of ice. Specimens of the granite and a striated block of quartzite were laid upon the table. He then described the rocks of the western extremity of the island, which consist of highly-metamorphosed stratified rocks—as gneiss, serpentine, dolomite, quartzite, and schists—extending from Port-na-Haven on the west to Brouach-Ladach, a distance of nine miles. At the latter point the superior deposits are seen resting on the metamorphosed sedimentary rocks, nearly at right angles to the planes of stratification. In lithological aspect and mineral character these rocks agreed so entirely with the "fundamental or Laurentian gneiss" of Sir R. Murchison, as occurring in the North-western Highlands and other parts of the world, that he had not the slightest hesitation in placing them as belonging to this, the oldest division of known sedimentary rocks. It thus appeared that both Cambrian and Laurentian rocks occurred further south in Scotland than had hitherto been recorded. Taking a general view of the group of deposits to which he had called attention, there were—1. The calcareous deposits in the central valley of the island, of Lower Silurian age. 2. The deposits from Ardnahuamh on the north to Balleochreoch on the south, of Cambrian age. He coincided with the view expressed by Professor Ramsay, that these strata were deposited under fresh water conditions, and exhibited several specimens with sun-cracks, ripple marks, rain drops, and what appeared to be annelid burrows—pointing out that if they had been deposited in an estuary of the sea, each inflowing tide would have kept the matrix sufficiently moist to prevent its cracking. 3. The metamorphic rocks in the west of the island, of Laurentian age. Their dip, and strike, and mineral character differ so widely from the other sedimentary rocks of the island as to furnish sufficient warrant for placing them in that position. He was not prepared to speak with any degree of certainty regarding the source of the materials constituting the basic conglomerate mass. These differ so widely from the granites found *in situ* in other parts of the Highlands, that he felt the necessity for tracing them to another source, and hoped he would not be thought to overstep the bounds of prudent speculation in suggesting that

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these erratics are the re-assorted materials of some great northern continent that has yielded to the gnawing tooth of time, leaving only these scattered fragments to attest its former existence. The portion of striated rock which he had laid before the meeting pointed to an agency adequate to the transport of such materials, and indicated that we should have to contemplate a glacial period deeper in time than had hitherto been suspected, when glaciers and icebergs planed down the hardest rocks and dispersed their fragments, obedient to the same great laws which still regulate the economy of nature.

III. *On the* Geology *of* Lewis. By James Thomson, F.G.S., V.P., and Henry Caunter. Esq.

(Read 10th April, 1873.)

The authors briefly described the relations of the gneissic or Laurentian rocks to the Cambrian strata of the island. The junction of the two formations is seen in the bed of a small stream that flows into the sea in the harbour of Stornoway; also in Garabost Bay, about seven miles to the east. The Laurentians dip N.W., while the lower members of the Cambrian dip at an angle of 23 deg. to the N.E. The basic rocks partake more or less of a gneissic character, but on the eastern side of the bay are seen passing with imperceptible gradations into a deep, dull, chocolate colour. On the western side there is a precipitous escarpment of conglomerate, in which it is difficult to trace the plane of stratification, but where this can be made out, it is seen to dip to the S.W., or unconformably to the lower members of the series. These beds have been termed by Sir Roderick Murchison, Upper Cambrian. The conglomerates are in two divisions. Near the base of the group the boulders and pebbles are all rounded, similar to those found along the more exposed parts of the West Coast, and consist of gneiss, granitic gneiss, and granite, the majority being of greyish colour. The boulders of the upper conglomerate are all more or less of red binary and ternary granite. Special attention was drawn to this fact, as corroborating the classification of the sections seen in Islay, as described by Mr. Thomson at a previous meeting of the Society; and specimens

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from both localities were placed upon the table and readily recognised as belonging to the same systems of rocks. The authors next described the more recent deposits of the island, beginning with the boulder drift, with its transported striated erratics, all of which belong to the Laurentian system, and are traceable to the west and north-west. They then referred to the gravels and drift-sand which overlie the remains of an extensive bed of peat seen in Stornoway Bay, where it attains a depth of fifteen feet. At the lower extremity of this bed, and only seen at extreme low tides, are numerous stumps of trees of considerable dimensions, the roots of which rest upon and pass down through a bed of clay, which forms the subsoil. From this it would seem that there has been an extensive subsidence of the island at a comparatively recent period, and that the climatal conditions must have been very different, during the time when such trees grew, from those which prevail at the present day. It is only recently, or since the Lewis passed into the hands of its present noble proprietor, Sir James Matheson, that any attempt has been made to cultivate trees in the island, and the conditions favourable to their growth seem to be found only in the more sheltered localities. Some interesting beds of clay and sand are found filling up the indentations that have been eroded out of the Cambrian conglomerate, at a time when this part of the island must have been depressed not less than 150 feet beneath its present level. The sections consist of (1) blown sand, underlying which is (2) clay varying from a few feet to 20 feet in depth, and which has long been wrought for making tiles and bricks. This is succeeded by (3) another bed of sand, containing numerous shells, which, however, are much broken. These, so far as examined, were of species found both in the pliocene beds and in the present seas; so that their age could not be accurately determined. The probability, however, is that they are, at most, not older than the upper pliocene beds of the Clyde. This point will be further elucidated when the authors have been able to obtain samples of the clay from underneath the old forest upon the shore already referred to, and fuller particulars will afterwards be given in the Transactions.

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PROCEEDINGS FOR THE YEAR 1872-73.

Annual General Meeting, October 31, 1872.

Mr. Edward A. Wünsch, *Vice-President*, in the Chair.

Annual Report by the Council.

Mr. D. Bell, Secretary, read the Report for the past year, of which the following is a summary :—

Membership.—The number of ordinary members on the roll is 156, showing some diminution as compared with late years, the new additions being scarcely sufficient to supply the vacancies caused by removal and otherwise. The Council believe this is due to temporary causes, and need not insist on the importance of keeping up the membership, in order that the work of the Society may be fully and efficiently carried on.

Ordinary Meetings.—These have been well attended, and a number of excellent papers has been read, chiefly on the geology of various parts of the West of Scotland. The Council acknowledge with pleasure the receipt of several communications from geologists at a distance. The specimens exhibited at the meetings have also been numerous and worthy of attention, and indicate no falling off in the zeal and success with which the all-important department of field-work is prosecuted by the members.

Occasional Lectures.—A few occasional lectures of a more popular cast than the papers read at the ordinary meetings were delivered during the session, and received with much favour.

Excursions.—The localities visited during the summer were Maryhill, Giffnock, Corrieburn, Craignethan, Beith, Milngavie, and Craigmaddie. These excursions were well attended, and brought under notice many interesting points relating to the districts visited.

Library.—Owing to the delay which took place in the early part of the session in the re-arrangement of the Library, the Council have to report that it has not been so largely availed of as in former years. They regret to announce that Mr. Naismith has felt it to be necessary to resign the office of Librarian, which he has held for several years to the satisfaction of the members. Mr. Richd. Neilson has agreed to undertake the duties, and the Council bespeak for him the co-operation of the members, to maintain the Library in due order, and conduct it to the advantage of the Society.

The Transactions of a large number of Scientific Societies in the United Kingdom and in other countries are regularly received; and these, with the donations acknowledged elsewhere, add much to the interest and usefulness of the Library.

Transactions.—During last session the first part of Vol. IV. of the Transactions was issued, and the Second Part of same volume is now at

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press. Messrs. John Young, V.P., James Armstrong, and D. Bell have been appointed as a Committee to superintend the publication of the Transactions—an arrangement which the Council believe will be found advantageous to the Society.

The Council are making arrangements with Messrs. John Smith & Son, Booksellers, St. Vincent Street, to keep a supply of copies of the Society's Transactions on hand, so that members and others may readily obtain them.

MUSEUM.—There were several additions made to the Museum during the past year, including an interesting series of Silurian and Liassic fossils presented by Dr. J. Paton Gloag, of Galashiels, formerly of Blantyre, one of the Society's corresponding members.

In entering upon another session, the Council rely on the co-operation of all in this city and neighbourhood who are interested in the advancement of geological science.

Mr. WRIGHT, C.A., Treasurer, read an Abstract of the Accounts for the year; (p. 337) and the Report was unanimously adopted.

Mr. JOHN YOUNG, V.P., made some remarks on the Silurian and Liassic Fossils which had been kindly presented to the Society by Dr. J. Paton Gloag. Mr. Young described at some length the leading characteristics of the various organisms in the collection, and the general conditions, so far as had been made out, under which they had existed.

A very large and fine *Orthoceras (Actinoceras giganteum)* was also exhibited, from the Carboniferous shale near East Kilbride, presented to the Society by Mr. Paton.

Thanks were voted to Dr. Gloag and Mr. Paton for their valuable donations.

Arrangements were intimated for the Conversazione and Exhibition of Specimens, proposed to be held in the Corporation Halls on the 6th December.

NOVEMBER 14, 1872.

Sir WILLIAM THOMSON, LL.D., F.R.S., &c., *President*, in the Chair.

Messrs. Robert Taylor, James Jarvie, and Thomas M. Campbell, were elected Resident Members.

The following donations to the Library were laid on the table :—

"The Physical Geology and Geography of Great Britain." By A. C. Ramsay, LL.D., F.R.S., Director-General of the Geological Surveys of the United Kingdom. (Third Edition.) *From the Author.*

"On the Glaciation of Iar-Connaught and West Galway." By G. H. Kinahan and M. H. Close, M.R.I.A. *From the Authors.*

"Transactions of the Edinburgh Geological Society."

"Transactions of the Berwickshire Naturalists' Club."

"Proceedings of the Manchester Literary and Philosophical Society."

CARBONIFEROUS CORALS.—Mr. JAMES THOMSON, V.P., F.G.S., read an elaborate paper "On the Classification of Carboniferous Corals." He

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stated that by the earlier naturalists corals were classified under the vegetable kingdom, and that it was only in 1727 that Peysonell first assigned them their true place as the calcareous deposits or secretions of animals. He then sketched the systems of classification that had been adopted by succeeding authors, down to the present time. He described the peculiarities in the structure of the leading groups of corals, and showed that in many instances the distinctions at present made between certain genera and species could not be maintained. Intermediate forms had been found, linking genera together that had hitherto been considered separate, and proving that they merged imperceptibly the one into the other. He urged the necessity of a more extensive and methodical comparison of these organisms in all stages of their development than had yet been accomplished, and suggested that this should be not only a national but a European work. The paper was illustrated by a copious selection of specimens beautifully prepared for examination, together with an exquisite set of fac-similes taken by a new process, the exactness and delicacy of which were much admired. One of the plates represented all the stages of development of one genus, from the secretion of the ova up to the perfect coral. This Mr. Thomson believed to be the only method by which a satisfactory classification of coralline life could be arrived at.

Mr. Wünsch, V.P., and other members, having made a few remarks in appreciation of the work which Mr. Thomson had accomplished,

The CHAIRMAN expressed the great pleasure he had in looking at the specimens which Mr. Thomson had submitted to the meeting, and at the beautiful representations of these organisms which he had succeeded in placing upon paper. The results were in the highest degree creditable to their friend's skill and industry, and he had much pleasure in conveying to Mr. Thomson the thanks of the meeting.

GLACIATION OF THE WEST OF SCOTLAND.—Mr. DUGALD BELL then read some "Notes on the Glaciation of the West of Scotland, with reference to some recently-observed instances of Cross Striation." (See p. 300.)

Arrangements were intimated for the Conversazione and Exhibition of Specimens to take place on 6th December.

6th Dec., 1872.—*Conversazione and Exhibition of Specimens.*

(See Supplement, p. 328.)

12TH DECEMBER, 1872.

Mr. JAMES THOMSON, F.G.S., Vice-President, in the Chair.

Mr. David Forsyth, M.A., was elected a resident member.

The SECRETARY intimated the following donations to the Library, which were received with due acknowledgment:—From Professsor de Koninck, of Liege, honorary member—(1) "Recherches sur les Animaux Fossiles. Première Partie. Monographie des genres *Productus* et *Chonetes*;" (2) "Nouvelles Recherches sur les Animaux Fossiles du Terrain Carbonifère

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de la Belgique." From Professor E. Hull, F.R.S., Director of the Geological Survey of Ireland, honorary member—"A Treatise on Building and Ornamental Stones." From Rev. W. Frazer, LL.D., Paisley, corresponding member—"Memorial Volume of the Opening of the Coats' Institute, Paisley."

SPECIMENS OF ORES.—Mr. ARCHD. ROBERTSON exhibited an interesting collection of ore specimens from various localities, including iron ores from the Scottish coal-fields, hematite from Cumberland, copper ore from the Ochil Hills, the celebrated "peacock" ore from Harvey Hill, Canada, &c. Mr. Robertson gave some notes regarding the position and circumstances in which these ores are found, and the methods employed for extracting them. A vote of thanks was awarded to Mr. Robertson for his kindness in bringing the collection before the meeting.

ROOFING SLATES.—Mr. DANIEL WILSON submitted a series of slates from Ballachulish, Easdale, Luss, North Wales, &c., illustrative of cleavage, curious distortions of strata, embedded crystals, and dendritic markings. He said these slates in Scotland belong to the Silurian formation, in Wales partly to the Silurian and partly to the Cambrian. They form a very extensive series of beds, often many hundreds of feet in thickness, and extending, with little or no interruption, for miles. They are generally associated with granites and traps, and largely interspersed with quartz veins in many localities. These beds must have been originally laid down in a tranquil sea-bottom, in the shape of fine mud or clay carried far out to sea by rivers, and gradually deposited over a very extensive area, and during a long period of time. Whether they ever contained any organic remains has been doubted, but in all likelihood they were not destitute of these, though all trace of them has been obliterated by the great changes which the strata have since undergone. Numerous outbursts of trap and granite, as well as intersecting dykes of the same kind, have baked and burned these strata, pressing and hardening the originally soft mud until it has attained the dense, compact form which enables it to bear more strain and weight for its thickness than any other rock known. The same agents have raised immense masses of the slate rocks from their original lowly bed to their present elevated position, forming the peaks of some of our highest mountains, and occupying every conceivable position, from the horizontal to the vertical. A remarkable change had also taken place in their structure, producing what is known as the cleavage of the rock, which is often at right angles to the lines of stratification, or rather which maintains over wide areas the same angle to the horizon, no matter how distorted the stratification may be. In our Scottish slate-rocks, throughout the entire Grampian range, the colours are light-blue and green. Among the slate isles of the Easdale district various shades of blue prevail. At Ballachulish it is a very dark blue, approaching to black. This slate is very fine in texture, hard and durable. The colours of the Welsh slates are more varied. In Carnarvonshire there are blue, red, grey, and green of various shades; while in Merionethshire blue is the prevailing colour. The blue and purple Welsh slates are formed of very fine mud, and are

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easily cut up, so that slate-pencils are fashioned out of some of them. Red and grey slates are the hardest and roughest—iron and silica, doubtless, giving to them their peculiar colours and qualities. Green is the only colour that loses its brightness, turning into a dirty white, as may be seen on the roofs of some old houses. The cleavage of slate forms a very interesting study, but on this he would not at present enlarge. He concluded by reading a note from Mr. White, of Easdale, descriptive of the strike and cleavage of the slate rocks in that district.

Mr. JOHN YOUNG, V.P., said it was a very remarkable property this, which the slates and some other rocks possessed, of splitting up into thin layers in a direction quite independent of the original lines of stratification. Various theories had been started to account for it—such as the *chemical*, that it was due to a chemical action among the particles of the rock; the *electrical*, that it was produced by currents of electricity passing through the mass; and the *mechanical*, that it was simply the result of great forces of compression to which the rock had been subjected, squeezing and lengthening out the particles in a particular direction. This last seemed to be the theory now most in favour with eminent authorities on the subject; though it was not denied that chemical and electrical influences may also, to some extent, have conduced to the result. He moved the thanks of the meeting to Mr. Wilson, and to the gentlemen at a distance who had favoured them with communications on the subject, and with the specimens now before them.

Mr. JAMES NEILSON, Jun., read a paper "On Some Sections of Carboniferous Limestone near Busby." (See p. 282.)

9TH JANUARY, 1873.

Mr. E. A. WÜNSCH, V.P., in the Chair.

The following were elected resident members:—Mr. John Granger, 166 Buchanan Street; Mr. Allan Granger, 166 Buchanan Street; Mr. John Jex Long, 12 Whitevale; Mr. John Goldie, Langside; Mr. James Moir, 143 West Campbell Street; Mr. David Rankine, C.E.; Mr. Thomas Scott, 1 North Ure Place; Mr. Robert Cameron, 61 Parliamentary Road; Mr. Thomas Hart, Renfield Street.

Mr. T. M. Barr exhibited a beautiful series of Liassic fossils from the neighbourhood of Scarborough, and Mr. Blair an interesting collection of Tertiary fossils from Lisbon.

Dr. JAS. BRYCE, F.G.S., then read an able paper on "The Upper Secondary Rocks of Skye and Raasay." He described the general succession of beds observed in Skye, from the Lower Lias at Lucy Bay to the Middle Lias at Broadford, Pabba, and Raasay; and the Upper Lias and inferior Oolite in the neighbourhood of Portree. Passing northwards, these are succeeded by beds still higher in the scale, till at Loch Staffin on the one side and Uig on the other, members of the Upper Oolite were found. He had also

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found indications of what appeared to be the equivalents of the "Purbeck beds" in England, and the fossils from these were now under careful examination. The paper was illustrated by maps and sections, together with a tabular view of the beds referred to, and a copious list of the fossils belonging to each horizon, including some new species not yet named.

Mr. Thomson, Mr. Bell, and Mr. Young having made a few remarks,

The CHAIRMAN conveyed to Dr. Bryce the cordial thanks of the meeting.

20TH JANUARY, 1873.

Sir WILLIAM THOMSON, F.R.S., LL.D., &c., President, in the Chair.

Professor EDWARD HULL, M.A., F.G.S., Director of the Geological Survey of Ireland, read some notes on "Signs of Earthquakes," and on "Colliers' Strikes."

In treating of the first-named subject he referred to various theories that had been propounded regarding the origin of earthquakes, and dwelt at some length on that which had been put forth by Mr. Mallet, to the effect that they resulted from the secular cooling of the globe, and the consequent shrinking of its outer crust. This theory seemed to him the most probable he had yet met with, and accounted for several geological facts, such as the contorted condition of the older strata, &c.

With regard to the second subject, Professor Hull referred to the great inconvenience, dislocation of trade, and loss to the nation which colliers' strikes were occasioning. He looked upon the gradual spread of education, and of some acquaintance with sound political economy, as the chief remedy for such unfortunate occurrences. He took occasion to say there was no reason for apprehension as to the supply of coal in our coal-fields, there being an abundant supply, with ordinary economy, for many centuries to come.

Mr. JOHN YOUNG, V.P., having made a few remarks, referring specially to what Professer Hull had brought forward on the subject of earthquakes,

The CHAIRMAN examined at some length the statements which, at least till lately, geologists had generally made regarding the earth having a molten interior throughout, covered by only a thin crust, and set forth the grounds on which he held such conclusions to be unwarranted and erroneous.

A vote of thanks to Proftessor Hull erminated the proceedings.

13TH FEBRUARY, 1873.

ANNUAL BUSINESS MEETING.

Mr. JOHN YOUNG, *Vice-President*, in the Chair.

Mr. Robert Granger, Mr. William Bertram, and Mr. Duncan Gray were elected Resident Members.

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The Society then appointed Office-bearers for the ensuing year, and the Council was declared to be constituted as under :—

President—Sir WILLIAM THOMSON, LL.D., F.R.S., &c., Professor of Natural Philosophy, Glasgow University.

Vice-Presidents—EDWARD A. WÜNSCH, JOHN YOUNG, JAS. THOMSON, F.G.S.

Joint-Secretaries—DUGALD BELL, 27 Lansdowne Crescent; JOHN BURNS, 352 St. Vincent Street.

Treasurer—JOHN WIGHT, C.A., 150 Hope Street.

Librarian—RICHARD NEILSON, 110 John Street.

Other Members of Council—ARCH. ROBERTSON, GEORGE R. ALEXANDER, JAMES ARMSTRONG, DANIEL WILSON, ÆNEAS M'MASTER, THOMAS NAISMITH, DAVID SANDEMAN, JAMES DAIRON, D. C. GLEN, DAVID ROBERTSON, JOHN ORR, ARTHUR PRATT.

Mr. G. H. KINAHAN, of the Geological Survey of Ireland, and Mr. R. L. JACK, of the Geological Survey of Scotland, were elected Corresponding Members.

The President, Sir WILLIAM THOMSON, F.R.S., &c., having taken the chair, delivered an address on the Internal Condition of the Earth, with special reference to its Fluidity and Rigidity. He reviewed the theories of Mr. Mallet and others, and performed some interesting experiments in illustration of his remarks.

On the motion of Mr. JAMES THOMSON, F.G.S., V.P., a cordial vote of thanks was awarded to the President for his instructive address.

13TH MARCH, 1873.

Mr. E. A. WÜNSCH, *Vice-President*, in the Chair.

Dr. JOHN DOUGALL exhibited some specimens of curiously-moulded rocks from the neighbourhood of the Transvaal River, Africa. These were at first thought to be the remains of an ancient city; but, on examination, it appeared they had been produced by natural causes—by chemical segregation acting on the materials of these rocks while in a plastic state. Mr. Robertson and others referred to nodules and concretions of similar form often found in the stratified clays of the West of Scotland.

Mr. THOS. M. BARR, C.E., read a paper on the Geology of the North-Eastern District of Yorkshire. (See p. 291.)

Mr. JOHN YOUNG, V.P., and Mr. JAMES ARMSTRONG read a paper on the Fossils of the Upper Carboniferous Limestone at Robroyston. (See p. 267.)

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27TH MARCH, 1873.

Mr. JAMES THOMSON, F.G.S., *Vice-President*, in the Chair.

Mr. William Keddie, F.R.S.E., Secretary to the Philosophical Society of Glasgow, was elected an Honorary Associate.

Mr. DAVID ROBERTSON, F.G.S., read some further notes on the Post-Tertiary Fossiliferous Beds of the West of Scotland, in continuation of the series of papers in conjunction with Mr. Crosskey. (See p. 241.)

Mr. JOHN YOUNG, V.P., read a paper "On the Probable Derivation of Certain Boulders found in the Till, near Glasgow." (See p. 259.)

10TH APRIL, 1873.

Mr. JOHN YOUNG, *Vice-President*, in the Chair.

Mr. Richard Howie, Academy, Airdrie, and Mr. Arthur R. Waddell, Rosemount, Airdrie, were elected Resident Members.

The CHAIRMAN read a note on a specimen of Carboniferous limestone from Braidwood, near Carluke, which contained in great abundance the *tests*, or shells of a species of Foraminifer, *Saccammina Carteri*. (See p. 266.)

Mr. ROBERT CRAIG made some remarks in continuation of his paper on the Boulder-Clay of North Renfrewshire, &c., explaining some points which he thought had been misunderstood in the discussion which took place at the time.

Mr. JAMES THOMSON, F.G.S., V.P., read a paper which he had prepared in conjunction with Mr. HENRY CAUNTER, on the Geology of Lewis. (See p. 315.)

24th APRIL, 1873.

Mr. JOHN YOUNG, *Vice-President*, in the chair.

Dr. Robert Brown, M.A., F.L.S., F.R.G.S., was elected an Honorary Associate of the Society.

Mr. JAMES DAIRON presented to the Society an interesting series of Graptolites from the lower Silurian or Llandeilo rocks of the Moffat district. He described at some length the structure of these extinct forms of Hydrozoa, illustrating his remarks by a number of carefully-executed drawings; and concluded by indicating the principal localities near Moffat where such fossils are obtained. Mr. Dairon received a cordial vote of thanks for his valuable donation and illustrative remarks.

Mr. JAMES NEILSON, Jun., read some further notes "On the Sections of Carboniferous Limestone near Busby." (See p. 282.)

Mr. DAVID ROBERTSON, F.G.S., read a note "On the Precipitation of Clay in Fresh and Salt Water." (See p. 257.)

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The CHAIRMAN read a paper, which he had prepared in conjunction with Mr. Robertson, "On the Composition of the Boulder and Laminated Brick Clays of the West of Scotland." The authors stated that their investigations had led them to regard as most probable the conclusion that the till, or unstratified boulder clay, had been laid down in water, and formed of materials which land-ice had carried seawards. The laminated brick-clays they viewed as having been formed by re-washings out of the boulder-clay. Only in one or two instances had they found organisms in the boulder-clay. These will be noticed more fully in the Society's *Transactions*, together with particulars of the clays that had been examined.

Mr. WÜNSCH, V.P., conveyed the thanks of the meeting to Messrs. Robertson and Young for their instructive paper.

The Society then adjourned till October.

SUMMER EXCURSIONS—1873.

	CONDUCTOR.
April 26—Thornton Quarries, East Kilbride.	Mr. JAS. NEILSON, Jun.
May 10—Loch Thom and Inverkip.	Mr. D. BELL.
,, 22—(Queen's Birthday.) Luss.	Mr. E. A. WÜNSCH, V.P.
,, 31—Trearne Quarries, Beith.	Mr. J. THOMSON, V.P.
June 14—Bowling and Neighbourhood.	Mr. JOHN YOUNG, V.P.
,, 28—Ballagan Glen.	Do.

To not a few members of the "Geological," the Summer Excursions form the most interesting and attractive feature of the yearly programme. To such members the hearing of papers read is at best a somewhat fatiguing operation. But a pleasant Saturday afternoon excursion to the Cathkin or Gleniffer braes, to the Campsie or Kilpatrick hills, to Craigenglen or Corrieburn, or to some noteworthy pit, or quarry, or railway cutting in the neighbourhood of the city—that is quite a different matter. The faithful hammer, dinted with bygone service; the bag, made more for use than ornament, are then drawn from their accustomed corner; old veterans turn out with all the alacrity of earlier days; facts are observed, theories are tested on the spot, and lessons learned in the library or class-room are put into practice in the field. There is the charm of the healthy exercise; the relaxation of friendly intercourse; sometimes the joy of discovery; always the pleasure of increasing one's acquaintance with those fragmentary records of the past which man was so long in learning to read, but from which he has already spelt out so wonderful a history. During the present summer, the members have already visited the neighbourhoods of East Kilbride, Inverkip, Luss, Beith, and Bowling. A great variety of subjects has thus been brought under their notice, and material has doubtless been gathered for several good "papers" during the coming session.

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Geologists may be divided roughly into two classes—the "physicists" and the "fossilists." The former look chiefly to the structure and outward aspect of the rock-formations, the changes which they have undergone, and the varied conditions of level, temperature, &c., to which these bear witness. The others make it their main business to collect, compare, and classify the "organic remains" which the same rocky strata contain. But while the members may individually belong to the one or other of these two divisions, both must be taken together—both must work in harmony, in order to anything like a proper or efficient study of the science; and in every excursion there is ample employment for both, though sometimes the one class may be said to have its "innings" rather than the other.

The first excursion, for example—that to the neighbourhood of East Kilbride—was for the purpose of examining the beds of lower Carboniferous limestone, shale, &c., there presented to view. This was specially a day for the fossilists, though the other division also found much to observe. The best section met with was at Thornton quarries, where there are 12 feet of useful limestone exposed, besides beds of fire-clay, ironstone, volcanic ash, and bituminous and calcareous shale, the whole being thickly capped with boulder clay. From its fossils, of which many good specimens were obtained, the upper bed of shale in this place has been identified with a similar bed overlying the "Hosie" limestone in the south hill of Campsie, and which, though now wrought out, was long a favourite resort of our local collectors. On this occasion Mr. James Neilson acted as guide, and pointed out the principal features of interest in the locality.

In the next excursion—namely, to Loch Thom and the neighbourhood of Inverkip—the physical geologists had their turn. Nothing "organic" was looked for, but the equivalents of the "Ballagan beds," which crop out in this district, were examined with much interest, particularly a fine section exposed at the south-west end of the loch, and showing some thirty beds of nodular limestone interstratified with dark-coloured shales, mixed with gypsum—very similar in appearance to what are found in the typical section at Ballagan. These beds, which occur also in the neighbourhood of Dumbarton and Port-Glasgow, may be regarded as the well-marked base of the Carboniferous system in the West of Scotland. They are here succeeded, in the direction of Wemyss Bay, by a considerable thickness of sandstone, which may be marked provisionally as Upper Old Red. The contact of the trap rocks in the vicinity with these deposits was also observed, and one or two well-marked "dykes," altering to some extent the adjacent strata, were traced to a considerable distance.

The following excursion (on the Queen's birthday) took the members a long step further back in time—from the Carboniferous and Old Red, they passed to the Silurian system as displayed in the slates of Luss on Loch Lomond. Here, again, the interest was mainly for the physicists; such phenomena as the *dip* and *cleavage* of the strata, and the evidences of ice-action on the hillsides and islands of the loch, being nearly all of a geological kind that came before them. But the place is one of exceeding beauty, and under the pleasant and instructive guidance of Mr. Wünsch, V.P., the "outing" was altogether a most enjoyable one.

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The succeeding trip made up, in some degree, to the fossilists for the little they had "bagged" on the two previous occasions. This time the "meet" was at Beith, under the experienced leadership of Mr. James Thomson, F.G.S., V.P. The locality has long been a favourite one with the members of the Society, the sections being numerous and the organic remains abundant and in excellent preservation. From the limestone quarries of Broadstone, Gateside, and Trearne, many excellent specimens were collected of Corals, Crinoids, Polyzoa, Brachiopoda, Cephalopoda, and Fishes. The party was accompanied on this occasion by the Hon. S. G. Percival, from London, a gentleman who has devoted considerable attention to the fossils of the Devonian and Carboniferous formations in England. Mr. Robert Craig, of Langside, a corresponding member of the Society, who is intimately acquainted with the geology of the district, also joined the members on the ground.

We have only space to mention that, in the Excursion to Bowling and neighbourhood, conducted by Mr. John Young, V.P., the members were, through the kindness of Mr. Robert Black, of Glenarbuck, admitted to the glen, for the purpose of examining the layer of plant remains of Carboniferous age interbedded with the trap rocks, which was discovered there by Mr. Young about two years ago. This interesting "find" corroborates the proof furnished by the beds of impure coal previously noticed in Auchintorlie Glen by the late Mr. Currie, of Bowling, that the great outflows of igneous rock-matter which form the Kilpatrick range of hills belong to the Carboniferous period.

The only other excursion to be noticed is that to Ballagan Glen, conducted by Mr. Young, whose admirable monograph on the locality is well-known to all students of Scottish Geology.

B.

26th June, 1873.

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SUPPLEMENT.

Conversazione and Exhibition of Specimens in the Corporation Halls, 6th December, 1872.

The following Reports, with a few alterations, are from the Edinburgh and Glasgow newspapers of 7th December:—

In the Corporation Galleries of Glasgow there was held last night certainly the finest geological exhibition that has ever been held in Scotland, and one which has probably never been equalled elsewhere in Britain; and in connection with it there was also held a very successful Conversazione. The exhibition was originated and carried out by the members of the Geological Society of Glasgow, regarding which we propose to make a few remarks before giving a description of the exhibition, inasmuch as its successful career is perhaps unique in the history of science.

Sketch of the Society.—The Geological Society of Glasgow had its birth in the month of May, 1858, and it may be said that it owes its origin to Dr. John Taylor, who, as the Professor of Natural Philosophy in Anderson's University, delivered a course of lectures on Geology to the popular evening class in the session of 1856-57. By means of those lectures, and the excursions which Dr. Taylor conducted, an amount of enthusiasm was kindled in many of the students which has never since been allayed. No sooner was the idea of a Geological Society formally ventilated (some of the members of Free St. Peter's Young Men's Society being among the first to move in the matter) than a number of Dr. Taylor's students readily cast in their lot, and thus the nucleus of the Society was formed. There were at first only some twenty or thirty members, but that number is now increased nearly tenfold.

The Society includes in its membership representatives of various ranks of life, professional, mercantile, and artisan. There are also a number of distinguished honorary members, such as Mr. Thomas Davidson, F.R.S., the eminent delineator of, and great authority on, the fossil Brachiopoda; Mr. Henry Woodward, F.G.S., F.L.S., &c., British Museum; Professor T. Rupert Jones, Royal Mil. Coll., Sandhurst; Professor Archibald Geikie, F.R.S., and others, who have contributed valuable papers to the Society. The *Transactions*, of which the fourth volume is now in course of publication, are supplied by request to all the Geological Societies, and to various other Scientific Societies at home; and abroad to the Smithsonian Institution, Washington; the Imperial Academies of St. Petersburg and Vienna; the Royal Society of Liège, &c. The first paper published by the Geological Society of Glasgow was the production of Mr. John Young, one of the Vice-Presidents of the Society, and Assistant-Curator of the Hunterian Museum, and formerly in the service of Messrs. Dalglish, Falconer, & Co.,

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Campsie. It was on "The Geology of the Campsie District," and is almost, if not quite, a model scientific monograph. It is now in the second edition. Another of the early papers in the *Transactions* was one by Mr. Archibald Geikie, F.R.S., now Professor of Geology in the University of Edinburgh, on "The Glacial Drift of Scotland." This memoir is now out of print as a separate publication, but we understand a revised edition is in course of preparation by the author. We might, if space permitted, refer to numerous other original memoirs in the Society's *Transactions*, the scientific value of which has been abundantly recognised by the most eminent geologists both at home and abroad. One or two of these imperatively claim a passing notice. There is a remarkable paper on "Geological Time," by Sir William Thomson, now President of the Society, the speculations of which were so startling that the paper formed the *pièce de resistance* of Professor Huxley's famous presidential address to the Geological Society of London in the year 1869. Sir William Thomson read another suggestive paper before the Glasgow Society, the subject of which was "Geological Dynamics." To working geologists, probably the most useful and valuable publication of the Society is the Supplement to Vol. III. of the *Transactions*. It is a paper on "The Carboniferous Fossils of the West of Scotland: their Vertical Range and Distribution," by Mr. John Young, with a "Catalogue of the Fossils and their Mode of Occurrence," and an "Index to the Principal Localities," by Mr. Jas. Armstrong, a former secretary of the Society. In the Catalogue and Index there are given the names, localities, &c., of no fewer than 676 distinct species of fossils found in the Carboniferous strata of Lancashire and the adjoining counties. The geology and palæontology of those strata in the counties referred to have been worked with such persistence, intelligence, and enthusiasm by the Glasgow geologists that there is perhaps no equally extensive area in the British Isles that is better known, or has made such valuable contributions to Geological Science during the last fifteen years. Private collections of fossil and rock specimens have been made, which, in their own special departments, are unequalled in extent and variety, and in almost every instance they have been made during the leisure hours and holidays of persons who have to earn their daily bread. From them many public museums have been largely enriched, and various tempting offers have been made with the view of securing selections from them to be taken to London and other places in the United Kingdom, to the Continent, and to America.

The Glasgow geologists prosecute the study of their favourite science, and maintain a healthy activity in their Society in a variety of ways. They hold meetings twice a month, from October till April, for the reading of papers, discussions, exhibition of new specimens, or the delivery of lectures, the latter being delivered by such men as Dr. David Page, Professor Edward Hull, M.A., F.R.S.; Dr. Robert Brown, Dr. James Bryce, and others. During the summer there are excursions to well-known spots that have a geological interest attaching to them. And, lastly, there are the Society's occasional public exhibitions, the one held last evening being the third that has taken place.

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THE EXHIBITION.—Almost the whole of the splendid suite of galleries were placed at the disposal of the Geological Society for the purposes of the Exhibition and Conversazione, but the exhibition proper was confined to the three large halls on the main floor. The east gallery was occupied almost entirely by Messrs. James Thomson, F.G.S., Young, and Armstrong. The first-named gentleman exhibited from his cabinet about seventy large cases containing Carboniferous fossils arranged systematically and classified in their zoological order, about thirty of the cases being in the central gallery, and specially illustrating the fossil Corals, the study of which the exhibitor has of late years made quite his own, and for which the British Association has voted special grants during several years, in order to enable him to carry on his special and painstaking researches. Mr. Thomson has in his own collection brought together the largest and most varied series of these Coral preparations known to science. He showed plates prepared for publication and museum purposes, produced by a new process, which enables him to obtain *fac-similes* of the most delicate coralline structures. In order to illustrate his series of Coral specimens, Mr. Thomson had a marine acquarium in which there were numerous Sea Anemones from the Firth of Clyde—these being the nearest relatives of the Polypes which secreted the coral substance in the primæval seas.

Amongst Mr. Thomson's other Carboniferous fossils we may mention his Labyrinthodons and Fish remains, both of which are probably unrivalled. Various groups of extinct Mollusca were illustrated very completely, some of the specimens showing the various stages of growth. In one case there was shown a specimen of Streptorhynchus, which is the largest yet discovered. Mr. Thomson equally well illustrated the fossil Polyzoa and Hydrozoa, and various other families; and his selections, while very extensive, were arranged most scientifically.

Mr. James Armstrong exhibited the greater portion of his extensive collection—fully 4000 specimens, illustrating about 500 species belonging to the local fossil Fauna and Flora of the Carboniferous system. The specimens were neatly mounted on blue-papered glass tablets, and labelled with scientific exactness and fulness. Mr. Armstrong showed typical representatives of Carboniferous Reptilia, Fishes, the various classes of shells, Polyzoa, Crustacea, Annelida, Sea-urchins, Encrinites, Corals, and Plants—the limestones, blackband ironstones, upper coal strata, shales, &c., chiefly of Lanarkshire and Ayrshire, being the sources whence most of them were obtained. Some of the specimens from the Airdrie blackband ironstone were Reptilian jaws, covered with their glistening enamel and bristling with teeth, as well as the thick armour-plated scales and other dermal armature characteristic of the Sauroid fishes of the coal measures; and the huge Rhizodus of the Possil ironstone was represented by its long trenchant teeth, about 10 in. long.

Mr. John Young exhibited a selection of the local Carboniferous fossils, most of which were obtained in the Campsie district. They embraced many rare and unique specimens (about 150 genera and 490 species). Mr. Young's fame as a local geologist was established many years ago, as it was to his

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care that the Local Committee of the British Association, meeting in Glasgow in 1855, committed the arrangements of the Geological Exhibition that was held on that occasion, and in connection with that matter he was employed during about twenty weeks. He has made the study of the microscopic Carboniferous fossils quite a specialty. When he began his researches, there were only four or five species of Entomostraca, or minute bivalve Crustacea, known in Scotch strata, while there are now nearly seventy, upwards of fifty of which are quite new to science. They have all been carefully described and named by Professor T. Rupert Jones, in conjunction with his scientific colleague, Mr. J. W. Kirkby, and are to be delineated for the Palæontographical Society. There were no Foraminifera known in Scotland belonging to the old sea-bottoms of the Carboniferous period prior to Mr. Young's labours; now, however, there are somewhere about ten distinct species, which Mr. Brady, F.Z.S., of Newcastle-on-Tyne, the great authority on fossil Foraminifera, has named, and is about to describe. The Chitons in Mr. Young's collection were much admired, as also his drawer of large fish teeth. In the same room with the foregoing there were shown various other collections, of which we may specially mention Mr. Anderson's series of oil-shales and products of their distillation through all the different stages to the finished products for market.

Mrs. Robert Gray, the wife of a well-known local ornithologist, excited great interest by a collection of Silurian fossils, which she had herself made in the Girvan district. It was as large as it was interesting, embracing many rare and new species, some of which have been named in honour of the discoverer by Mr. Thomas Davidson and other eminent Palæontologists. There were drawers of Trilobites, Brachiopods, and Graptolites, all fine and well-preserved; in short, Mrs. Gray's collection of Girvan Silurian fossils is probably the most complete in the country. It is evidence of great diligence and research, and an excellent example of what a lady collector can do.

Mr. Wünsch, Vice-President of the Society, exhibited a most interesting series of minerals from the neighbourhood of Vesuvius and Etna, and from the famous volcanic district of Central France, long ago described by Mr. Poulett Scrope; and equally interesting was his series of fossil specimens illustrating an ancient forest which existed at Laggan Bay, in the Island of Arran.

A valuable and interesting collection of diamonds and gems was exhibited in a small glass case by Mr. George Edward & Sons, jewellers, Buchanan Street. The collection attracted a great deal of attention. Mr. Archibald Robertson exhibited a number of very fine metalliferous minerals, including well-crystallised specimens of quartz or hæmatite, Canadian copper ores, specular iron, &c. Mr. Glen (of Glen & Ross, engineers) was amongst the most prominent exhibitors of metalliferous minerals, his specimens embracing illustrations of almost all the ores from which the useful metals are obtained. Many of the specimens were exceedingly beautiful, and some were of great rarity.

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In the western gallery the lion's share of the exhibiting space was given up to Mr. David Robertson, F.G.S.—a gentleman whose assiduity and success as a collector is somewhat extraordinary. Probably no naturalist has a more extensive acquaintance with the marine fauna of the Firth of Clyde, as revealed by the dredge, of which Edward Forbes used to sing with such great gusto; and in conjunction with Rev. H. W. Crosskey, F.G.S., late of Glasgow, the gentleman referred to has devoted an immense amount of attention to the Post-Tertiary shells of the West of Scotland. Mr. Robertson's collection was greatly admired from its completeness in the departments of the recent British shells—those of the Post-Tertiary period, from around the Firth of Clyde, and from Denmark and Norway. The arrangement was most commendable and instructive, inasmuch as a comparison of the organic remains of corresponding deposits could most readily be instituted. The Ostracoda and Foraminifera were also abundantly represented, there being many hundreds of species in Mr. Robertson's cases. This collection included, in addition, a beautiful case of recent Polyzoa and Hydrozoa. One great feature of this collection was that the specimens were all collected by the exhibitor personally in the localities named in his descriptions.

Few persons have worked to more purpose in the department of the Graptolites, an extinct sub-class of the Hydrozoa, than Mr. James Dairon. That gentleman had on view an extensive collection of these fossils from the neighbourhood of Moffat, and from the same district he exhibited many illustrations of the Silurian organic remains. From the Whitby district, on the Yorkshire coast, Mr. Dairon also exhibited many Liassic fossils; and from the Isle of Wight he had a number of Tertiary fossils. Many of Mr. Dairon's specimens were of considerable interest on account of their great beauty and perfect condition.

Our space is already exhausted, otherwise we might allude to numerous other collections which had more or less special features to distinguish them. Mr. Kirsop showed some beautiful specimens of fossil wood from the West Indies; Mr. Burns, some specimens of sand, gravels, clays, concretions, and minerals; Mr. Pratt, some Carboniferous and Tertiary minerals and rocks; Mr. Orr, some Carboniferous plants; and Mr. Bell, a suite of striated rocks from the boulder-clay, and some Liassic fossils from the Isle of Skye. Altogether, the exhibition held last night was of the very greatest scientific interest, and such as the Western Metropolis alone could bring together.

The Conversazione and Exhibition of Geological Specimens, held under the auspices of the Glasgow Geological Society, attracted a numerous assemblage to the exhibition halls yesterday evening. Among the gentlemen present were—Sir Peter Coats; Colonel Campbell, Blythswood; Mr. James Young, of Kelly; Professor Allen Thomson; Rev. Dr. Fraser, Paisley; Rev. Dr. Cloag, Blantyre; Rev. George Cameron, Dr. Bryce,

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Dr. Connal, Dr. Dick, Dr. Muirhead, Dr. Morton, Dr. Grossart; Councillors Fergus, Collins, and Steel; Provost Shaw, Maryhill; Provost Bruce, Hillhead; Messrs. Wm. Foote, A. L. Fowler, D. Sandeman, Robert Walker, Robert Ross, Alex. Gillies, T. W. Brown, William Keddie, R. L. Jack, John Robertson, J. Mossman, Arch. Robertson, Robert Gray, G. J. Dickson, Wm. Mitchell, John Kirsop, George Smith, Nathaniel Dunlop, David Rowan, J. Farquhar, James Deas, George Thomson, John Mann, Alexander Drew, Bernard Eckhout, Sig. Schuman, James Anderson, W. R. W. Smith, Geo. R. Alexander, Richard Chalmers, Alex. S. Baird, &c. The proceedings were of a most interesting character—the only limitation to the success of the gathering being the absence of Sir William Thomson, President of the Society, who was to have taken part in the proceedings, and Professor Geikie, Director of the Geological Survey, from whom a letter had been received expressing regret at being unable to be present, but who showed his interest in the meeting by sending for exhibition the original Geological Map of Sutherland used by Sir Roderick Murchison in working out the structure of the Northern Highlands.

The company began to assemble about half-past seven, and ladies and gentlemen continued to crowd the rooms until about an hour after that time, when Mr. Wünsch, Vice-President, explained that the President, Sir William Thomson, who was to have presided, had unfortunately, and to his own regret, been suddenly called away to London on business. In his absence, he proposed that Colonel Campbell should take the chair.

Colonel CAMPBELL said he was extremely sorry at the absence of Sir William Thomson, the distinguished President of the Society; but he was sure that, when they considered the cause which had called him away was that of science, they would not regret it so much. He was sure that Sir William's presence at the starting of the "Challenger," with which a scientific voyage was to be made round the world, would be a certain forecast of the success of the cruise of that ship. He had been asked to say a few words about the evening's entertainment. All he desired to remark was that they saw around the room the most beautiful specimens of the geological formations of some of the earliest periods; and while Geology was the history of the past, it was a science upon which they could build their knowledge step by step; but that knowledge could only be gained by arduous labours, and those specimens which were displayed had only been brought together after years of toil, of trouble, and of persevering research.

Later in the evening the company was addressed by

Mr. WÜNSCH, Vice-President, who said—Ladies and gentlemen, the Office-bearers of the Society will be happy to give any information with regard to the collection of fossils, minerals, &c., now spread out before you. We hope, therefore, that you will freely make use of their services; but, in addition to the fund of information thus placed at your disposal, it may, nevertheless, be desirable to give you a more generalised view of the specimens and fossils placed upon the tables—not anything like a formal

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catalogue or a repetition aloud of the hard names upon them, and which are already sufficiently hard to read, but merely a summary as to what may be inferred from them. If you look at the large diagram before you, representing all the various Geological Formations, you will perceive in about the middle of it the space that is apportioned to the Carboniferous series—that is to say, those strata on which we are now standing, and which fill up not only the valley of the Clyde, but nearly the whole of the great central valley of Scotland. To these great Carboniferous beds we mainly confine ourselves, and these alone it is the object of our Society to illustrate in detail by specimens. For this purpose a number of our members have toiled from year to year to collect together the scattered fragments, and to resuscitate to the mind's eye the wonderful fauna and flora of a former world. Geology has been said by one of our great authorities to be nothing but the "physical geography of former ages restored;" and so it is, in the same sense in which a modern traveller might bring back from a far-off country plants, fishes, birds, and animals, to give you an idea of its productions and climate. In the same manner, our indefatigable collectors have brought you specimens from a far-off world; and so successful have they been that we say, with a pardonable egotism, but with perfect truth, that the collections you see before you are, as far as the Carboniferous series are concerned, more extensive and more complete than anything similar, either in the British Museum, or in Jermyn Street, or in any other Museum at home or abroad. Nor have we had any Government grants or any extraneous assistance whatever. Our collections are entirely the result of the labour of private individuals—of men whom, perhaps, you may look upon with a kind of pitying smile for wasting the best part of their lives in collecting senseless stones. If you meet these men upon the streets of Glasgow, as intent upon the pursuit of their daily avocations as any other men, you would never suspect that they lead a second and an inner life full of rich thoughts to them—that after spending every available leisure moment in collecting and observing on the hill-side, on the shore, in the quarry and the coal-pit, they return at night laden with their spoils, and "waste the midnight oil" in classifying and arranging them. Let me endeavour to give you an idea of the thoughts that pass through the mind of a geologist. If you look at our diagram of the Carboniferous series, you will find that it is made up of a succession of beds of limestone, sandstone, coal, and shale, repeated over and over again in every possible variety, very uninteresting to look at to a non-geological eye, we must admit, either in nature or on the map; and if you look at the shells, as we now exhibit them, disconnected from their native beds—pale, discoloured, flattened by pressure—they may convey no meaning to you, but to a geologist they tell the story of a tranquil sea of clear water, in which shells of all sizes and colours lived and flourished, surrounded by corals of brilliant hue, by fish darting in and out, chased by monster saurians in search of their prey. The evidence of all this life is now entombed in a few feet of dull grey limestone. Overlying this you will meet with a bed of sandstone or shale, and in it you find innumerable impressions and casts of leaves and branches,

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and stems of tree ferns, thus bringing before your mind's eye the time when the clear sea bottom must have been overspread by the muddy waters of some large river—some primeval Ganges or Mississippi—carrying with it all kinds of vegetable *debris*, and carrying it deep in its slime. You look a few feet higher in the section, and you perceive that the sea has actually been silted up—a low shore has been formed, and a dense vegetation has grown up and decayed where it grew, century after century, for you now have before you a seam of coal—a black, solid mass of vegetable matter petrified. You look a few feet higher, and you perceive that the primeval forest, prostrate by a hurricane or an earthquake, has once more been covered up by thick beds of sand and mud, but not for ever. Life has been upon the globe, and will endure—fresh generations of trees and plants spring up, and again and again fill the earth with that inexhaustible store of condensed fuel which, by the bounty of nature, is meant to be. From mere deposits, gradual and quiet, of limestone, mud, and sand, we can lead you on to higher and grander phenomena; we can show you the same tropical vegetation prostrate by violent earthquakes, and buried beneath thick showers of ashes vomited forth by volcanoes in violent eruption; we can show you remains of whole forests, trunks of trees, numberless branches, and even fruit cones, overtaken by such a fate—locked up for thousands of ages in the iron grip of hardened volcanic ash, and now revealed, in all their marvellous beauty of structure by a blow of the geological hammer. But time and breath and your patience would fail if I were to speak of other geological periods, as long or longer than the Carboniferous age, the history of which is only a single chapter in the immense volume of nature. All one can say on an occasion like this is, that if you will muster courage to go through the alphabet with us, you can learn to read for yourselves a history, or series of histories, compared with which the oldest written, or even traditional histories, are but of yesterday. Every one may not have a turn of mind for collecting fossils, or for entering upon the minutiæ of geological study; but every man who prides himself on his intellectual culture cannot afford to remain unacquainted with the leading facts in geology, for it is a link in the endless chain by which all sciences and all facts are connected together. But even on the most utilitarian ground we have the strongest claim upon your interest, and upon that which follows from it—your active and practical support. Were it not for the treasures of the earth brought to light by mining, and by the happy union of those two main levers in modern civilisation—coal and iron—we might well ask, would Glasgow be what it is at present? It is the professed geologist who is the pioneer for the practical mining engineer. He is like the honey-bird of the Indians, guiding them to the rich deposits of stored-up honey, in the hope of getting his share of the spoil. But does he always get it? We hope he does; but I am afraid we cannot say we are in the same favourable position in our country and in our line of pursuits. We have been content to toil on without reward or hope of reward, though in some shape or other it should come ultimately. Let me then conclude with the noble words spoken by the veteran naturalist and geologist,

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Professor Agassiz, when, on his return from his recent scientific expedition, he addressed the citizens of San Francisco on the subject of acquiring collections for public use and for Museums; and if his arguments told upon a young community, should they not tell with tenfold force upon the citizens of the second city in the British empire? Professor Agassiz said—"I hold that it is the duty of those who have the means to help those who have only their head, and who go to work on the faith of encouragement from their more prosperous neighbours. So I think one of your duties, besides fostering and nursing the interest you individually feel for science, is to arouse the general interest in the community, which will make every true patriot, every lover of his State, every philanthropist, every man who has the heart to leave a good repute and an honourable memory, desirous of contributing to your progress." (Applause.)

Mr. JAMES YOUNG, of Kelly, proposed a hearty vote of thanks to Sir Wm. Thomson, and to the Vice-Presidents and members of the Geological Society, for the pleasant entertainment they had provided. The call was warmly responded to; and on the proposition of Dr. BRYCE, thanks were accorded to Col. Campbell for presiding.

The proceedings then terminated.

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ABSTRACT of the ACCOUNTS of the GEOLOGICAL SOCIETY of GLASGOW,

For Year Ending 30th September, 1872.

REVENUE.

RECEIPTS.

Subscriptions—			
Arrears for 1870-71, 4 at 10s.,	£2 0 0		
Subscriptions for current year, 135 at 10s.,	67 10 0		
New Members' Subscriptions, 17 at 10s.,	8 10 0		
		£78 0 0	
Petty Receipts,		2 7 11	
Drawn from Bank,		56 0 2	
Balance due to the Treasurer,		0 16 2½	
		£137 4 3½	

DISBURSEMENTS.

Balance due to the Treasurer at the close of last Account,		£2 1 7½
Printing Transactions, to Account,		17 18 9
Lithographing and Drawings,		13 8 0
Rent, Taxes, Insurance, and Attendance,		13 1 0
Postages, Parcels, and Advertising,		12 16 5
Printing Cards, Circulars, and Stationery,		14 2 6
Miscellaneous Disbursements,		6 9 9
Lodged in Bank,		57 6 3
		£137 4 3½

STOCK.

Liabilities current,		£33 6 9	
Balance, for net Stock,		176 16 4	
		£210 3 1	

Cash in Bank on Deposit Receipt,	£29 0 4		
,, ,, on Current Account,	6 2 9		
		£35 3 1	
Publications, Fossils, and Casts,		175 0 0	
		£210 3 1	

GLASGOW, 15*th October*, 1872.—We have examined the Accounts, of which the foregoing is an Abstract, with the Vouchers, and find the same correct.

(Signed) RICHD. NEILSON, *Auditor.*
JAMES MACAULAY, *Auditor.*

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LIST OF OFFICERS AND MEMBERS

At 2nd May, 1874.

MEMBERS OF COUNCIL.

President—Sir WILLIAM THOMSON, F.R.S., D.C.L., LL.D., &c., Professor of Natural Philosophy, University of Glasgow.

Vice-Presidents—EDWARD A. WÜNSCH, JOHN YOUNG, JAS. THOMSON, F.G.S.

Joint-Secretaries—DUGALD BELL, 27 Lansdowne Crescent; JOHN BURNS, 352 St. Vincent Street.

Treasurer—JOHN WIGHT, C.A., 150 Hope Street.

Librarian—RICHARD NEILSON, 110 John Street.

Other Members of Council—ARCHIBALD ROBERTSON, DANIEL WILSON, JAMES ARMSTRONG, THOMAS NAISMITH, THOMAS M. BARR, HUGH M'PHAIL, DAVID SANDEMAN, JAMES DAIRON, D. CORSE GLEN, DAVID ROBERTSON, F.G.S., JOHN ORR, ARTHUR PRATT.

HONORARY MEMBERS.

Thomas Davidson, F.R.S., F.G.S., Brighton
David Page, LL.D., F.R.S.E., F.G.S., Newcastle-on-Tyne
Archibald Geikie, F.R.S., F.G.S., Director, Geological Survey of Scotland, Edinburgh
T. Rupert Jones, Professor of Geology, Royal Military College, Sandhurst
James W. Kirby, Pirnie Colliery, Leven, Fifeshire
Henry Woodward, F.G.S., British Museum, London
Joseph H. M'Chesney, Professor of Geology, University of Chicago
Edward Hull, M.A., F.G.S., Director, Geological Survey of Ireland, Dublin
Sir William Thomson, F.R.S., LL.D., &c., Professor of Natural Philosophy, Glasgow University, *President*
John Young, M.D., F.G.S., Professor of Natural History, Glasgow University
M. L. De Koninck, Professor of Natural History, Liege

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HONORARY ASSOCIATES.

James Bryce, LL.D., F.G.S., High School, Glasgow
Thomas Struthers, Academy, Larkhall
James Croll, Geological Survey, Edinburgh
Rev. H. W. Crosskey, F.G.S., Birmingham
James Horne, Eastbourne, Sussex
James Farie, Canonbury, London
William Keddie, F.R.S.E., Glasgow

CORRESPONDING MEMBERS.

Rev. William Fraser, Free Church Manse, Paisley
T. B. Grierson, M.D., Thornhill, Dumfriesshire
Rev. Dr. Gordon, Manse of Birnie, Elgin
Rev. Dr. Paton J. Gloag, Manse, Galashiels
Dr. John R. S. Hunter, Daleville, Braidwood, Carluke
James Hunter, Ironmaster, Coltness Ironworks
David Kerr, Wemyss Colliery, Fifeshire
James Linn, Livingstone
Rev. Alexander M'Bride, North Bute
Rev. Hugh Mitchell, Craig, Montrose
George Sommervile, Lennoxtown
Alexander Winchell, Professor of Geology, University of Michigan
Rev. Edward Myers, F.G.S., 20 Summerhill Terrace, Birmingham
D. R. Rankin, Surgeon, Carluke
William Grossart, Surgeon, Salsburg, Holytown
Robert Slimon, Surgeon, Lesmahagow
Robert Craig, Langside, Beith
John Dougall, M.D., 115 Paisley Road
T. F. Jamieson, F.G.S., Ellon, Aberdeenshire
John Ward, Longton, Staffordshire
William Molyneux, F.G.S., Burton-on-Trent
R. L. Jack, of H.M. Geological Survey of Scotland
G. H. Kinahan, of H.M. Geological Survey of Ireland
James Geikie, F.R.S.E., F.G.S., of H.M. Geological Survey of Scotland

RESIDENT MEMBERS.

Those marked * are Life Members.

Addison, James, 532 St. Vincent Street
Aitken, Robert J., 116 St. Vincent Street
Alexander, George R., 11 Sardinia Terrace
Allan, Archibald B., 3 Argyle Terrace, Queen's Park
Anderson, Richard, Oil Works, Uddingston
Annan, Thomas, Burnbank Road, Hamilton
Armstrong, James, 16 Albert Drive, Crosshill

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Bailey, James L., S.S.C., Ardrossan
Bannerman, David, Corn Exchange Buildings, Hope Street
Barr, Thomas M., 21 Rose Street, Garnethill
Baxter, William, 14 Gibson Street, Hillhead
Bennie, James, 11 Prospect Street, Edinburgh
Bertram, Peter, Stationer, Argyle Street
Bell, Dugald, 27 Lansdowne Crescent, *Secretary*
Bisset, R., 5 India Street
Blair, James, 186 Sauchiehall Street
Brown, Alfred, 112 Trongate
Buchanan, James, 36 London Street
Burnet, John, 150 St. Vincent Street
Burns, John, 352 St. Vincent Street, *Secretary*

Cameron, Donald, 42 Hutchison Square
Cameron, Robert, 61 Parliamentary Road
Campbell, T. M., 8 Carrick Street
Carrick, John, 4 South Albion Place
Cochran, Hugh, 13 George Street
Connal, M., Virginia Buildings
Colquhoun, H., M.D., 17 Grosvenor Terrace
Coghill, William, 263 Argyle Street
Cox, C. C., Retford
Cranston, John James, 119 Graham Street
Crawford, Ebenezer, Eagle Foundry, Port-Dundas
Crawford, W. C., Eagle Foundry, Port-Dundas

Dairon, James, 4 Garden Street
*Dalglish, Robert, 28 St. Vincent Place
Dewar, Peter, Cartcraigs, Pollokshaws Road
Dilley, Henry, 30 Hope Street
Drew, Alexander, 73 Gordon Street
Duncanson, John, Builder, 12 Derby Street
Dunsmore, John, Kirkintilloch
Dunn, William, Coalmaster, 2 Oswald Street

Eadie, George, 1 Hampden Terrace, Cathcart
Evans, Mortimer, C.E., 97 West Regent Street

Faulds, Robert, jun., 61 Parliamentary Road
Farquhar, John, Lenzie
Ferguson, William, F.G.S., Kinmundy, near Mintlaw, Aberdeenshire
Fergus, Andrew, M.D., 41 Elmbank Street
Fisher, Donald, 194 West George Street
Fletcher, Thomas, 37 Bath Street
Foote, William, 189 Trongate

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Forsyth, David, M.A., 19 Great Western Road
Forsyth, Matthew, 191 West George Street
Fyfe, John, 32 Candleriggs

Galbraith, 153 Queen Street
Gale, James M., C.E., Corporation Water Works
Gardiner, Archibald, 97 West Regent Street
Gilmour, Dr. Thomas, 49 King Street, Tradeston
Glen, D. Corse, C.E., Greenhead Engine Works
Goldie, John, 68 Gordon Street
Gordon, John, Architect, 175 Hope Street
Gossman, Adam, 38 Cadogan Street
*Graham, William, 70 Miller Street
Grainger, Thomas, Gas Works, Partick
Grainger, Allan, 166 Buchanan Street
Grainger, John, 166 Buchanan Street
Gray, James, M.D., 15 Newton Terrace
Gray, James, at Miss Kilpatrick's, 12 Dalhousie Street
Gray, Duncan, 2 Allanton Terrace
Grant, James, 27 Douglas Street

Hamilton, Archibald, C.E., Clyde Navigation Engineer's Office
Hamilton, James, Architect, 113 West Regent Street
Harvie, J., 27 Union Street
Hart, Thomas, 63 Renfield Street
Hogg, C. P., C.E., 175 Hope Street
Hood, Walter, 2 Royal Exchange Square
Horne, R. R., Mount Vernon Colliery, Tollcross
Howie, Richard, Academy, Airdrie
Hunt, Edmund, C.E., 87 St. Vincent Street
Hunter, Matthew, Manufacturer, 9 Cochran Street
Hutcheson, Alexander, 119 Hope Street
Hutton, William R., Chemist, 77 Renfield Street
Hyslop, Peter S., 97 West Regent Street
Hull, Edward, F.R.S., F.G.S., Geological Survey, Dublin

Jarvie, James, 27 Union Street

Kerr, Hugh B., Mrs. Christie's, 30 Paterson Street
Kerr, William, 27 West George Street
King, Thomas, 110 Hill Street, Garnethill
Kirsop, John, 98 Argyle Street
Knox, Adam, 25 Belgrove Street
Knox, John, Coal Merchant, 25 Bath Street

Lean, Daniel, Manufacturer, Reid Street, Bridgeton
Leggatt, Rev. William, 153 Greenhead Street
Lindsay, Charles, C.E., 39 Devon Street
Long, John Jex, 12 Whitevale

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M'Ara, Alexander, 2 Oswald Street
M'Arthur, D., 26 Bothwell Street
M'Aulay, James, 34 Renfrew Street
M'Beth, Daniel, Ashburn, Ascog, Rothesay
M'Clelland, Andrew S., 140 St. Vincent Street
M'Donald, Henry, 158 George Street
M'Dougal, Daniel, Beechwood, Crosshill
*M'Farlane, George, C.A., 163 West George Street
M'Master, Æneas, Canal Bank House, Port-Dundas
M'Phail, Hugh, Nitshill

Maddever, Dr., Rothesay
Mason, Robert, 29 West George Street
Maxwell, Andrew, 88 Cadogan Street
Miller, James, 285 Crown Street
Miller, John (Messrs. J. Black, Drew, & Co.), 23 Royal Exchange Square
Miller, James, Dalmarnock Cottage, Dalmarnock
Miller, J., 13 Robertson Street
Miller, Maxwell, 31 Washington Street
Milligan, W. F., 11 Stonefield Terrace
Moir, James, 143 West Campbell Street
Monro, Alexander, 34 Dundas Street, City
Moore, Henry, 49 West George Street
Moore, William, 49 West George Street
Morris, Robert, 2 Oswald Street
Morrison, William, jun., 11 Bothwell Circus
Mossman, John, 83 North Frederick Street
Muckle, Alfred, C.E., Caledonia Railway Company's Offices
Murray, David, 13 Fitzroy Place
Murray, W. F., 47 Garngad Hill
Murdoch, James B., Langside
Muir, George, 229 High Street

Naismith, Thomas, 233 Duke Street
Napier, J. W., 249 Renfrew Street
Neilson, Richard, 110 John Street
Neilson, James, 16 Whitevale Street
Neilson, James, jun., 641 Duke Street
Norman, John, 20 Windsor Terrace, St. George's Road

Orr, John, 91 John Street, Bridgeton

Peebles, Robert, 58 Holmhead Street
Pratt, Arthur, 162 Hope Street
Pratt, David, 80 Great Clyde Street

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Rattray, John, 94 Renfield Street
Reid, Charles, Portioner, 261 Stirling Road
Renwick, John, Mary's Place, Maryhill
Reid, John, Joiner, Yorkhill Gate, Partick
Reid, John, Hyndford Cottage, Lanark
Reid, J. G., 37 St. Vincent Crescent
Robertson, Dr. James, Clydeside House, Renfrew
Robertson, Archibald, Manufacturer, 25 Queen Street
Robertson, David, F.G.S., 108 Woodlands Road
Robertson, David, 201 West George Street
Robertson, John, 33 West Cumberland Street
Robertson, Joseph, 110 John Street
Rosenburg, Paul, 46 West George Street
Ross, Robert, Writer, 176 St. Vincent Street
Rowan, Thomas, Chemist, 194 St. Vincent Street
Russell, James, 3 Clyde View, Bridgeton
Russell, Richard, 59 Robertson Street

Sandeman, David, 11 John Street
Schuman, Sigismund, 12 Royal Bank Place
Scott, Thomas, 1 North Ure Place
Smellie, Thomas D., 213 St. Vincent Street
Smith J. P., C.E., 67 Renfield Street
Smith, John, Eglinton Iron Works, Kilwinning
Sommerville, Joseph, 51 Raglan Street
Steel, James, 1 Seton Terrace
Stewart, James (A. S. Henry & Co.), 29 Royal Exchange Square
Stewart, Robert, 28 Abbotsford Place
Stewart, John, 12 Ure Place
Stewart, Thomas P., 29 Queen Street

Taylor, William, 144 Wellington Street
Thomson, George, 69 Ingram Street
Thomson, James, F.G.S., 276 Eglinton Street, *Vice-President*
Tuckwell, J., 288 Buchanan Street
Turnbull, J., 96 Renfield Street

Waddell, Arthur R., Rosemount House, Airdrie
Walker, David, Teacher, 201 Sauchiehall Street
Walker, Robert, jun., 8 Ingram Street
Walker, R., Union Villa, Helensburgh
Watson, William W., City Chamberlain, County Buildings
Welsh, Thomas, 540 St. Vincent Street
White, James, 220 Hope Street
Whitelaw, Alexander, 87 Sydney Street
Wight, John, C.A., 150 Hope Street, *Treasurer*

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Wilson, Daniel, 87 Hope Street
Wilson, Hugh, 53 Garscube Road
Wingate, W. G., 12 Garthland Street
Wünsch, E. A., 146 West George Street, *Vice-President*
Wyper, William, 171 Pollokshaws Road

Young, James, 103 West Regent Street
*Young, John, Hunterian Museum, College, *Vice-President*
Young, George, 13 Hope Street
Young, James, Lochview, New Kilpatrick
Yule, John, 23 Carlton Place

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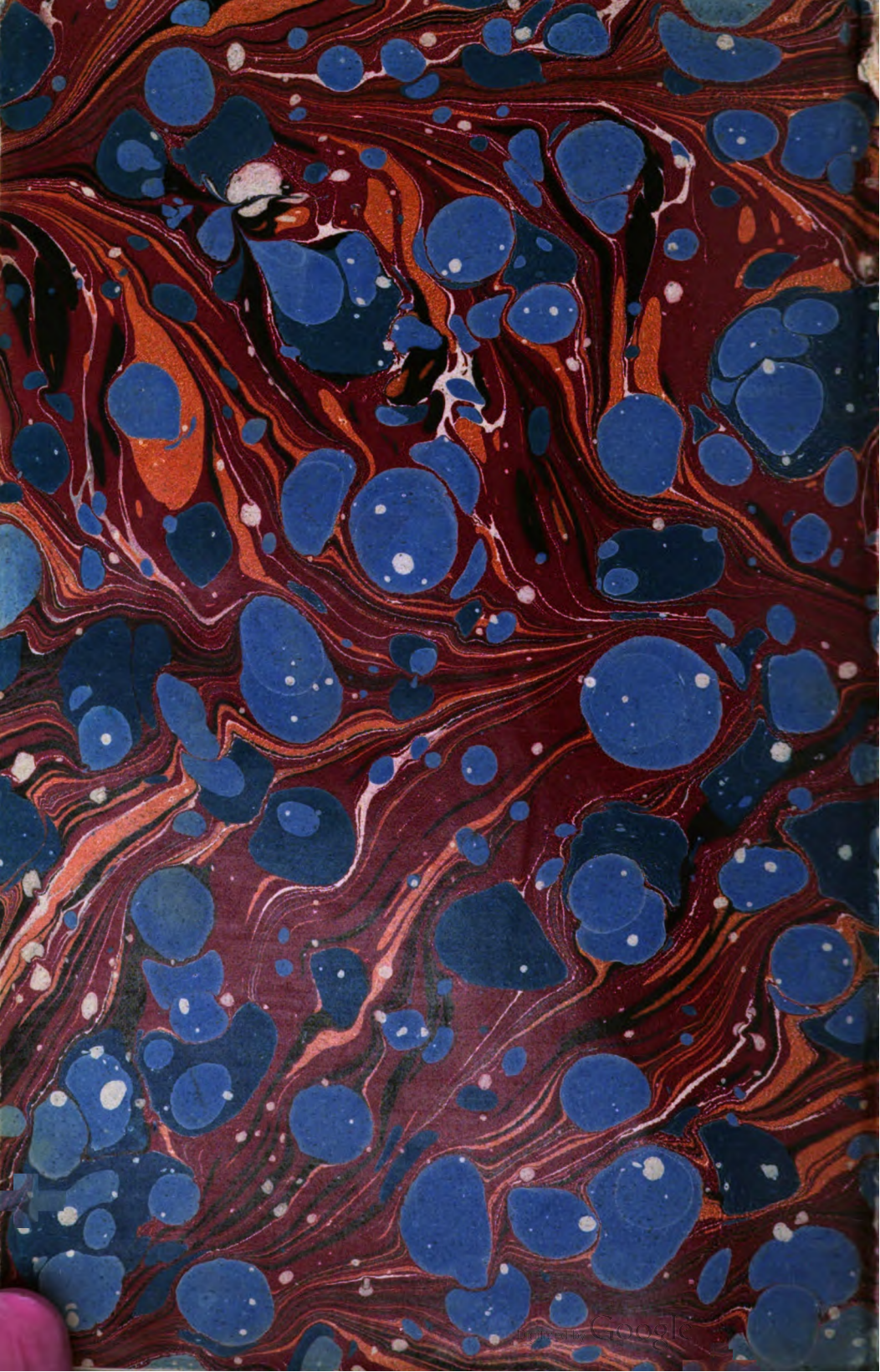
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